UNIVERSITY OF VIRGINIA
REACTOR DECOMMISSIONING PLAN

Prepared For
University of Virginia

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February 2000

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ACRONYMS and ABBREVIATIONS

ACGIH	American Conference of Government Industrial Hygienists
ALARA	As Low As Is Reasonably Achievable
ALI	ANNUAL Limit on Intake (see 10 CFR 20)
ANSI	American National Standards Institute
AP	Activation Products
ARA	Airborne Radioactivity Area (see 10 CFR 20)
ARWT	Advanced Radiation Worker Training
ASME	American Society of Mechanical Engineers
BRWT	Basic Radiation Worker Training
CAM	Continuous Air Monitor
CAVALIER	Cooperatively Assembled Virginia Low Intensity Educational Reactor
CDE	Committed Dose Equivalent
CFR	Code of Federal Regulations
cm	centimeter
cpm	counts per minute
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration (see 10 CFR 20)
DCGL	Derived Concentration Guideline Levels
$DCGL_W$	Weighted DCGL
$DCGL_{EMC}$	Elevated Measurement Comparison DCGL
DDE	Deep Dose Equivalent (see 10 CFR 20)
DECON	Decontamination Decommissioning Option
DOC	Decommissioning Operations Contractor
DP	Decommissioning Plan
dpm	disintegrations per minute
EDE	Eye Dose Equivalent (see 10 CFR 20)
EH&S	UVA Environmental Health and Safety Group
ENTOMB	Entombment Decommissioning Option
EPA	U.S. Environmental Protection Agency
g	gram, a unit of mass
GET	General Employee Training
GM	Geiger-Mueller
GTCC	Greater Than Class C
HEPA	High Efficiency Particulate Air (Filter)
HEU	High Enriched Uranium
HP	UVA Health Physics Department
HPGe	High Purity Germanium Detector
IH	Industrial Hygiene
LLRW	Low-Level Radioactive Waste
LSA	Low Specific Activity (see 49 CFR)
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*, NUREG-1575
micro-R	micro-Roentgen, 10^{-6} Roentgen

mR	milli-Roentgen, 10^{-3} Roentgen
mrad	milli-rad, 10^{-3} rad
mrem	millirem, 10^{-3} rem
MSDS	Material Safety Data Sheet
MSHA	U.S. Mine Safety and Health Administration
mSv	milli-Sievert (unit of dose equivalence, see 10 CFR 20), 10^{-3} Sievert
MW	Megawatt
NCRP	National Council on Radiation Protection and Measurements
NEC	National Electric Code
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NIST	U.S. National Institute of Standards and Technology
NQA	Nuclear Quality Assurance
NTS	Nevada Test Site
NRC	Nuclear Regulatory Commission
OSHA	Federal Occupational Safety and Health Acts
pCi	pico-curie, a unit of radioactivity (2.22 disintegrations per minute) 10^{-12} curie
PCM	Personnel Contamination Monitor
POL	Possession Only License
PQM	Project Quality Manager
QA	UVA Quality Assurance Organization
QC	Quality Control
R	Roentgen
rad	unit of absorbed radiation dose
RCA	Radiological Control Area
RCRA	Resource Conservation and Recovery Act
RDS	UVA Reactor Decommissioning Scope
rem	Roentgen Equivalent man (unit of dose equivalence, see 10 CFR 20)
RESRAD	USDOE Computer Code for Residual Radioactivity Calculations
RO	Reactor Operator
RP	Radiation Protection
RPM	Radiation Protection Manager
RPP	Radiation Protection Program
RSC	Radiation Safety Committee
RSHM	Radiation, Safety and Health Manager
RSO	Radiation Safety Officer
RWP	Radiation Work Permit
SAFSTOR	Safe Storage Decommissioning Option
SDE	Shallow Dose Equivalent (see 10 CFR 20)
SNM	Special Nuclear Material
SP	Safety Program
SS	Stainless Steel
Sv	Sievert (unit of dose equivalence, see 10 CFR 20)
TEDE	Total Effective Dose Equivalent (see 10 CFR 20)

TLD	Thermoluminescent dosimeter
USAEC	U.S. Atomic Energy Commission
USDOE	U.S. Department of Energy
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
USNRC	U.S. Nuclear Regulatory Commission
UVA	University of Virginia
UVAR	University of Virginia Reactor

1.0 SUMMARY OF PLAN

1.1 INTRODUCTION

1.1.1 Overview

The UVAR has been variously used since 1960 to provide training for Nuclear Engineering students, and research by all Departments of Engineering and the Departments of Physics, Chemistry, Biology, and Medicine. A profile of this reactor is presented in Table 1-1. In July, 1998, the University of Virginia (UVA) ceased reactor operations at the UVA Reactor (UVAR) located in Charlottesville, Virginia. The objective of this Decommissioning Plan is to conduct decontamination (DECON) of the UVAR and removal of radiologically-contaminated and/or radioactive materials, equipment, components, and soil, to obtain release to unrestricted use by the U.S. Nuclear Regulatory Commission (USNRC). The term "unrestricted use" means that there will be no future restrictions on the use of the site.

The regional location of the UVAR facility (USNRC License R-66) is shown in Figure 1-1; Figure 1-2 depicts the UVA Reactor facility site and adjacent UVA structures; the UVAR site is depicted on Figure 1-3. Figures 1-4 through 1-6 presents plan views of the three floors of the UVAR. This Decommissioning Plan has been prepared using the guidance and format of NUREG -1537 Rev. 0, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors* (Ref. 1.1).

Figure 1-1 Map of Area Surrounding the UVAR Site

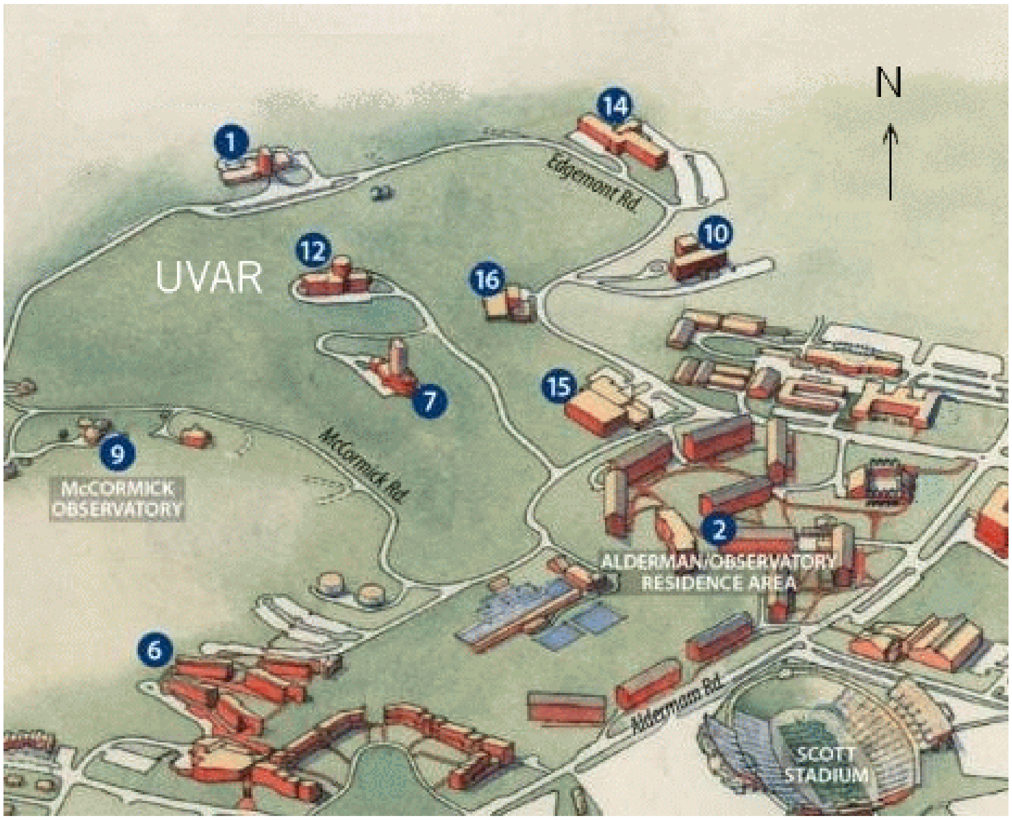


Figure 1-2 Northern University of Virginia Campus

Location 12: Reactor Facility
Location 1: Aerospace Research Laboratory
Location 2: Alderman Observatory Residence Area
Location 6: Hereford Residential College
Location 7: High Energy Physics Laboratory
Location 9: McCormick Observatory
Location 10: National Radio Astronomy Observatory
Location 14: Shelbourne Hall
Location 15: Slaughter Recreation Facility
Location 16: Special Materials Handling Facility

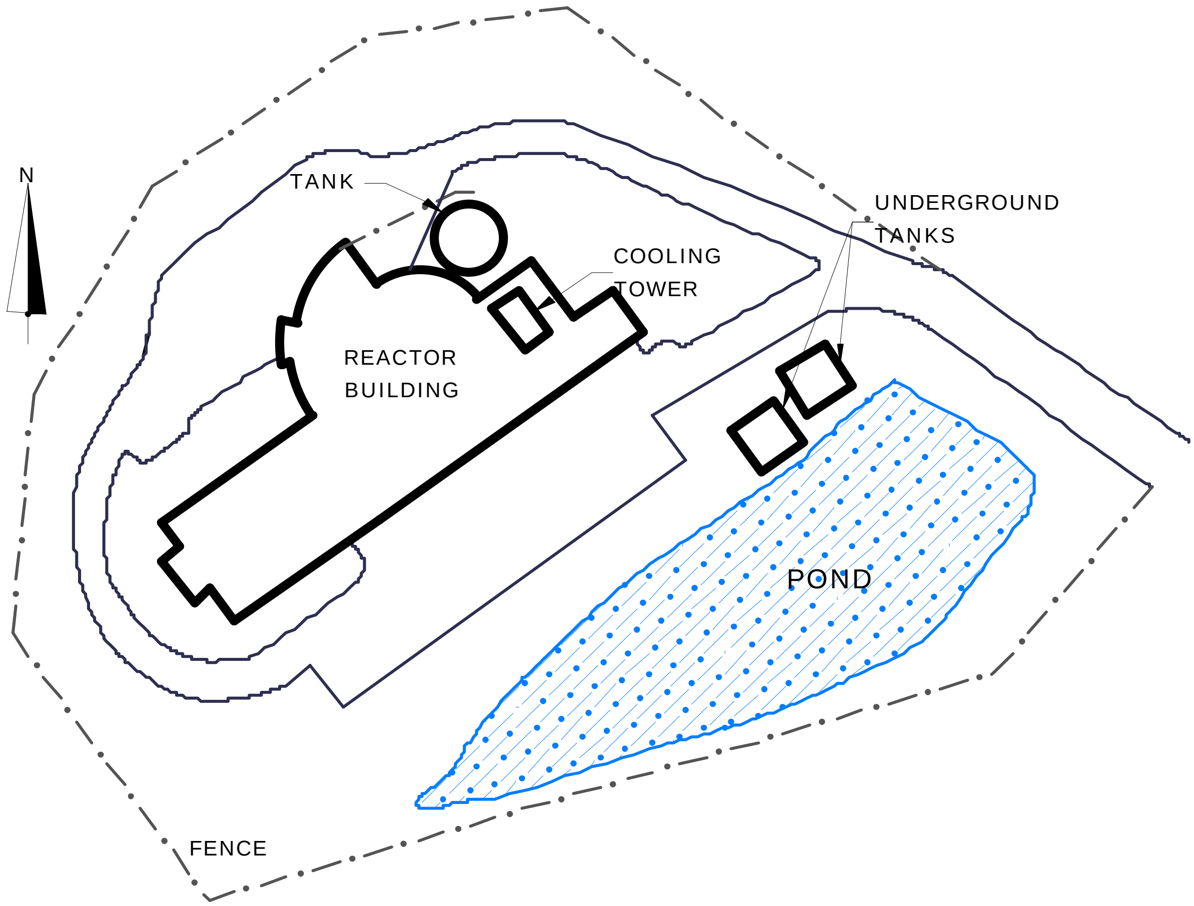


Figure 1-3 University of Virginia Reactor Site

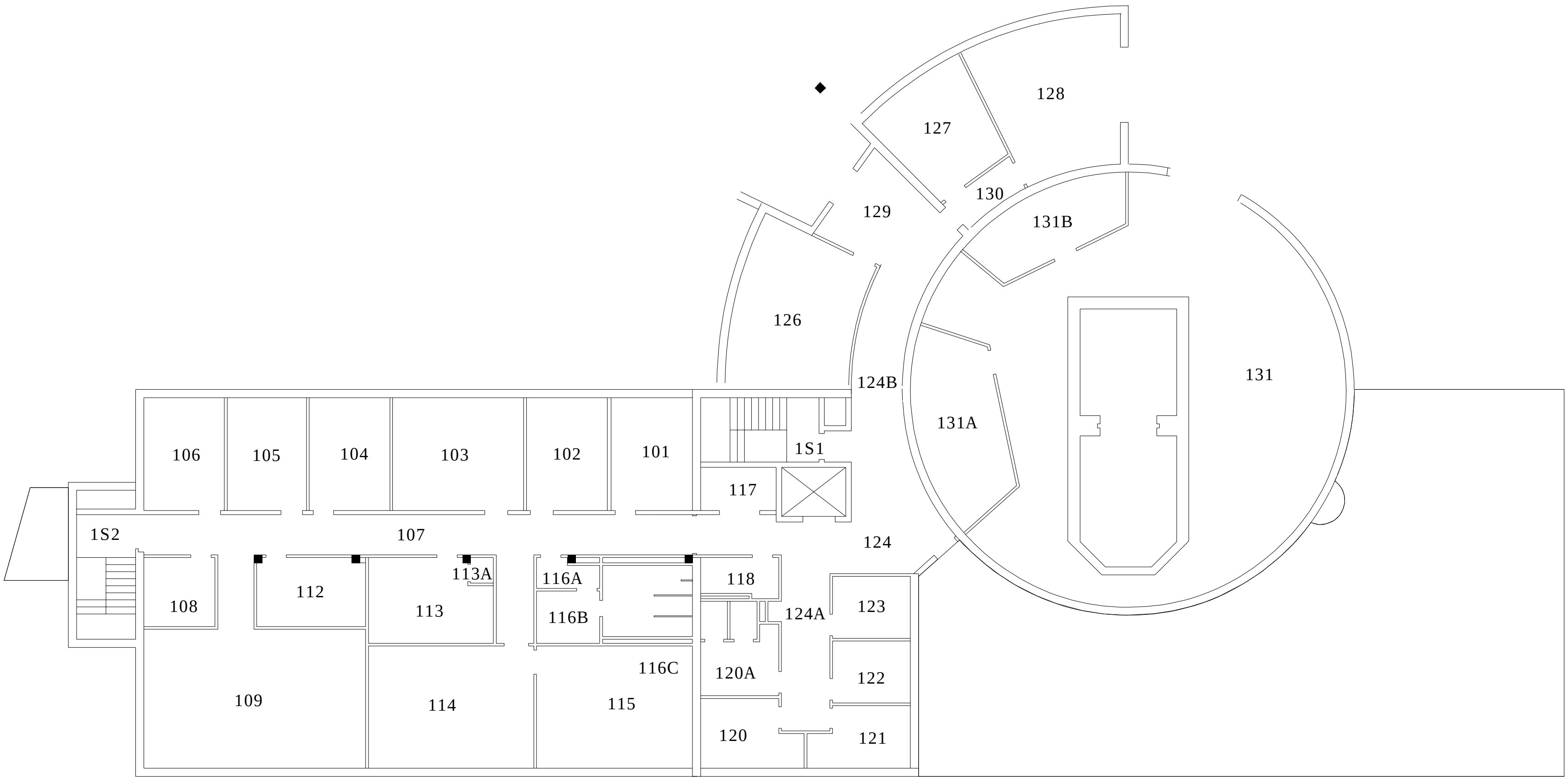


Figure 1-4 UVA Reactor First Floor Plan View

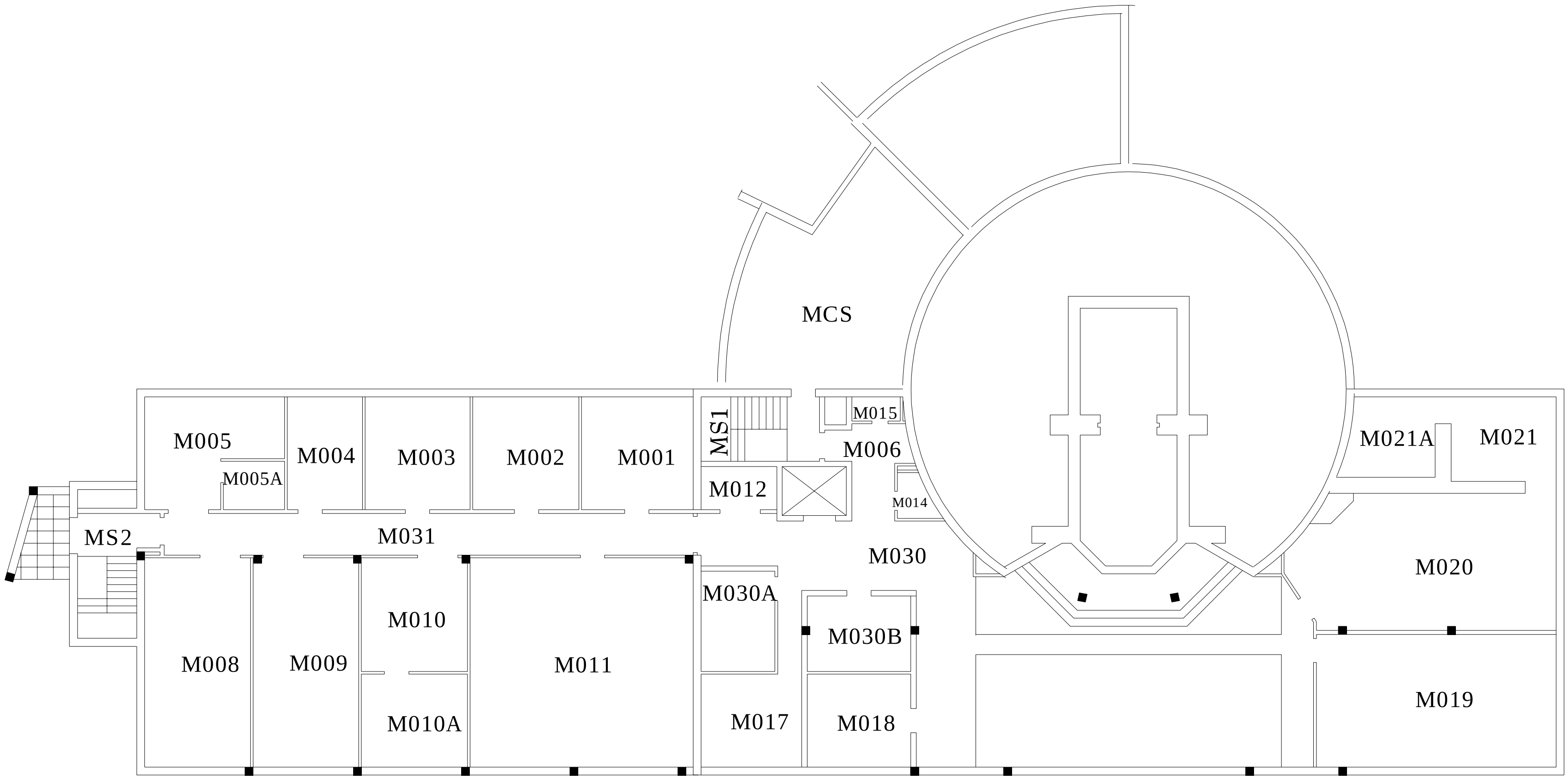


Figure 1-5 UVA Reactor Mezzanine Floor Plan View

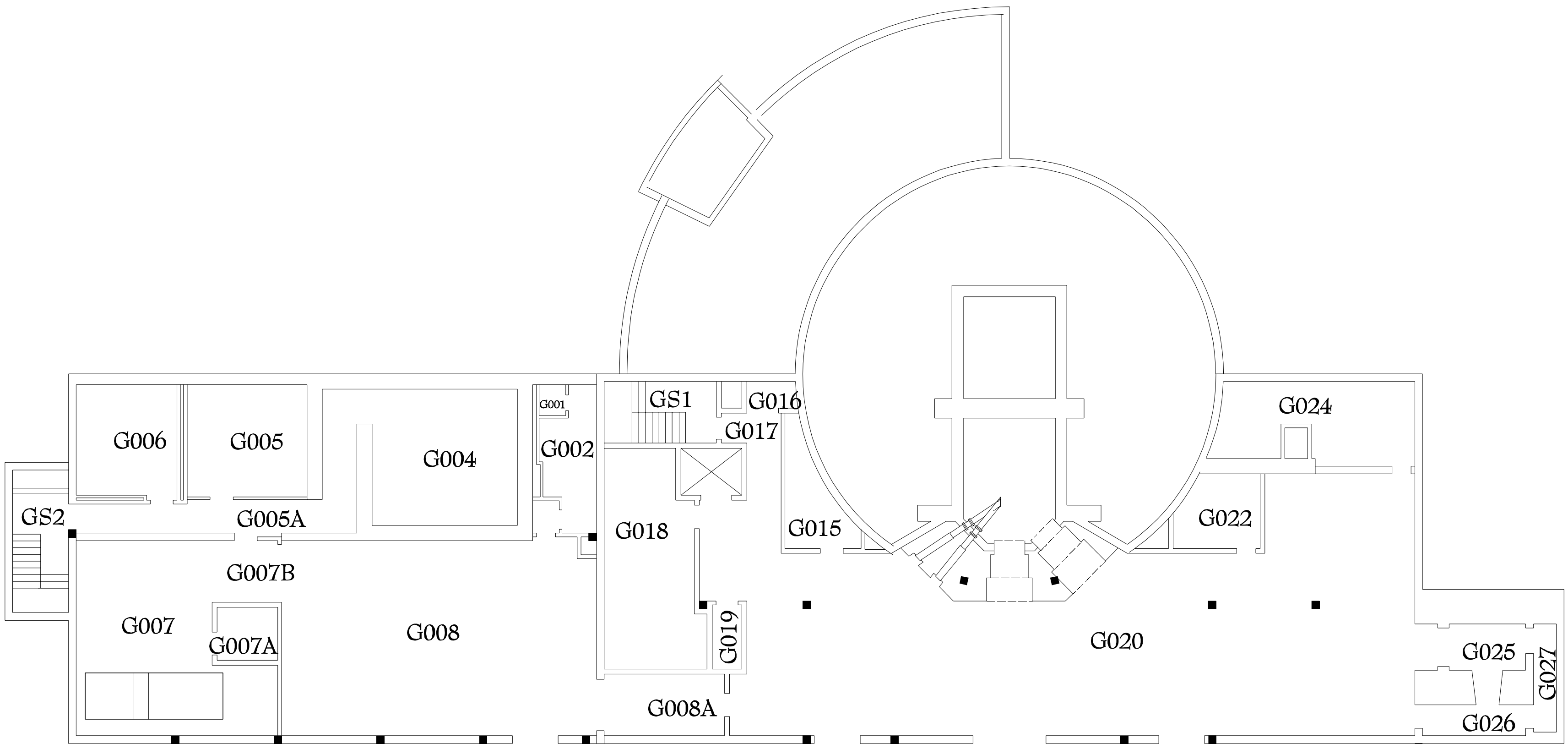


Figure 1-6 UVA Reactor Ground Floor Plan View

Table 1-1 Profile of University of Virginia Reactor

Item Description	UVAR
General Reactor information:	
Owner:	University of Virginia
Operator:	University of Virginia
Licensee:	University of Virginia
Architect/Engineer	Babcock & Wilcox
Nuclear Design:	EG&G, Idaho
Construction:	Castle Construction Co.
Principal Uses:	Training and Research
Reactor Operation and Authorization:	
Initial Criticality:	June 1960; increased licensed power from 1 to 2 MW Jan. 1971
Date Secured:	July 1, 1998
USNRC Utilization Facility Lic. #:	R-66
USNRC Facility Docket #:	50-62
Reactor Specifications:	
Maximum Power, Steady State, MW(t):	2 MW
$\varphi_{thermal}$ Steady State, Graphite Reflected (nv):	2.2×10^{13}
$\varphi_{thermal}$ Steady State, Water Reflected (nv):	0.17×10^{13}
Specific Power (kW/kg ^{235}U):	273.97
Core Power Density, (kW/l):	27.97
Fuel Material:	LEU, U_3Si_2
Fuel Uranium Content, vol-% ^{235}U:	3.67%
Uranium Enrichment, % ^{235}U:	<20%
Fuel Element Geometry:	Flat Plate
Element Cladding Material:	Aluminum
Element Cladding Thickness:	0.015 in
Core Configuration:	Square Array
Core Active Height:	23.5 in
No. of Available Fuel Positions:	64
Coolant:	Light Water
Moderator:	Light Water
Reflector:	Graphite or Water

1.1.2 Decommissioning Plan Provisions

This Decommissioning Plan provides the following:

1.1.2.1 A description of the present radiological condition of the UVAR facility and site environs.

1.1.2.2 A description of the planned approach to be employed to decommission the UVAR.

1.1.2.3 Descriptions of the methods that will be utilized to ensure protection of the health and safety of the workers and to protect the environment and the public from radiological hazards associated with UVAR Decommissioning Project activities.

1.1.2.4 A description of UVAR physical security and material accountability controls that will be in place during the various phases of Decommissioning Project activities.

1.1.2.5 A description of the radioactive waste management and disposal.

1.1.2.6 A cost estimate for decommissioning the UVAR, and the source of funding for these activities.

1.1.2.7 A schedule for the UVAR Decommissioning Project.

1.1.2.8 A description of the quality assurance program applicable to the UVAR Decommissioning Project.

1.1.2.9 A description of the Training Program to be established for personnel performing work in support of the UVAR Decommissioning Project.

1.1.2.10 An Environmental Report concerning the expected impact of performing the activities involved in the UVAR Decommissioning Project.

1.2 BACKGROUND

Site and Facility History

University of Virginia

The property, on which is situated the University of Virginia Reactor Site and Facility, was acquired in 1817. It was reported that the property was originally purchased by Thomas Jefferson to supply fire wood to the various buildings on the campus at that time, most of which were heated with wood. The UVAR reactor was constructed between 1957 and 1960. Figure 1-5 shows the current UVAR configuration.

Figure 1-3 shows the UVAR yard areas which are included in the scope of this Decommissioning Project. The specific yard areas to be addressed in the Decommissioning Project herein are listed below.

Underground Tanks	(~800 ft^2 area)
Transfer Tank	(~ 80 ft^2 area)
Site Environs	(~1,640 ft^2 area)

Figure 1-4 shows the UVAR first floor areas which are included in the scope of this Decommissioning Project. The specific rooms to be addressed in the Decommissioning Project herein are listed below.

Reactor Room, Rm 131	(~2,648 ft^2 area)
Instrument Shop, Rm 128	(~305 ft^2 area)
Shipping Room, Rm 127	(~175 ft^2 area)

Figure 1-5 shows the UVAR mezzanine floor areas which are included in the scope of this Decommissioning Project. The specific rooms to be addressed in the Decommissioning Project herein are listed below.

Demineralizer Room, Rm M021	(~246 ft^2 area)
Mechanical Room, Rm M020	(~507 ft^2 area)
HP Lab, Rm M019	(~492 ft^2 area)
Mezzanine Crawl Space, Rm MCS	(~576 ft^2 area)
Former HP Lab, Rm M005	(~288 ft^2 area)
Former Hot Lab, Rm M008	(~338 ft^2 area)

Figure 1-6 shows the UVAR ground floor areas which are included in the scope of this Decommissioning Project. The specific rooms to be addressed in the Decommissioning Project herein are listed below.

Heat Exchanger Room, Rm G024	(~297 ft^2 area)
Source Storage Room, Rm G022	(~110 ft^2 area)
Hot Cell, Rm G025	(~93 ft^2 area)
Large Access Facilities	(~84 ft^2 area)
Instrument Storage Room, Rm G015	(~114 ft^2 area)
Storage Room, Rm G018	(~317 ft^2 area)
Ground Floor Area, Rm G028	(~2,216 ft^2 area)
Wood Shop, Rm G008A	(~126 ft^2 area)
Machine Room, Rm G008	(~1,042 ft^2 area)
Counting Room, Rm G004	(~451 ft^2 area)
Rabbit Room, Rm G005	(~229 ft^2 area)

UVA Reactor

UVA was granted a construction permit for the UVA Reactor on September 13, 1957 from the U. S. Atomic Energy Commission (USAEC). Immediately thereafter, working with the

Architect/Engineer Castle Construction Company of Charlottesville, Virginia, UVA proceeded with construction of a facility to house the UVA Reactor and supporting systems (e.g., Instrumentation and Control Systems, Forced Cooling System, Water Demineralization System, Ventilation/Exhaust System, Radiation Monitoring Systems, etc.). Following construction and reactor hardware installation, the UVA Reactor was brought to initial criticality in June of 1960. The UVAR was operational from that date until July 1998 when the reactor was permanently shut down. UVA has requested that the USNRC issue an amendment to the UVAR facility license to place the reactor in Possession-Only-Amendment (POA) status.

Current Facility Status

It is anticipated that the UVA Reactor, situated in Room 131, will be placed in "Possession-Only-Amendment" (POA) status, under Amendment No. 25 to the USNRC License No. R-66, early in the year 2000 (UVA Request dated August 16, 1999, Ref. 1-2). The UVAR is presently inoperable. All reactor fuel elements were removed from the reactor pool and returned to DOE.

UVAR building utility services required for facility operation and maintenance under POA status conditions are active.

Manually-actuated and automated fire alarm systems in the UVAR are operational.

UVAR security and radiological alarm systems required by TS will remain active and normal.

The UVAR water demineralization system remains operational.

1.2.1 Reactor Decommissioning Overview

Prior to implementing the decommissioning actions described herein, the UVAR will have been cleared of all extraneous fixtures, equipment and materials. Remediation will be required for the reactor and associated equipment, the reactor room, the demineralizer room, the heat exchanger room and in the buried tanks and vaults. In other areas of the facility only minor remediation requirements are anticipated. The general activities to complete the Plan objectives are:

1.2.1.1 Remove the reactor grid plate, the reactor support structure, equipment from the reactor pool and activated concrete from the reactor pool.

1.2.1.2 Perform additional decontamination and dismantlement of the structure and equipment associated with the UVAR in accordance with this plan.

1.2.1.3 Perform additional decontamination and dismantlement activities in outdoor areas and on equipment associated with the UVAR in accordance with this plan.

1.2.1.4 Prepare the decommissioning generated material for release or disposal (as appropriate) throughout the activities. Either decontaminate and release the material as non-radioactive waste, or package for transport as radioactive waste.

1.2.1.5 Ship all radioactive waste off-site to a licensed waste processor or disposal facility. In the event that no acceptable licensed disposal facility is available, waste may be retained onsite for interim storage.

1.2.1.6 Perform and document the final radiological survey(s) and submit a request to the USNRC for performance of confirmatory surveys and subsequent release of the former Reactor Facility to unrestricted use, through a termination of the reactor license.

1.2.2 ESTIMATED COST

The cost estimate is consistent with the scope of work covering D&D of the UVA Reactor. D&D of the UVAR will be accomplished without dismantlement of the building. The detailed estimated cost to decommission the UVAR licensed areas is presented in the Decommissioning Cost estimate for the UVA Reactor Facility, Charlottesville, VA (Ref. 1-3). This project is estimated to cost $3,065,000. The decommissioning estimate was generated using Xtreme PM℠ (Ref. 1-4). A cost breakdown is given in Table 1-2 below.

Table 1-2 Decommissioning Cost Summary - UVA Reactor

D&D Operation	Labor Plus Travel & Living $1000's	Waste Processing & Transport $1000's	Equipment Contracts & Supplies $1000's	Waste Shipping & Disposal $1000's	Total Cost $1000's
Reactor Confinement Structure	$149	$32	$37	$64	$282
Reactor, Pool & Pool Contents	$70		$47	$325	$442
Old Labs & Structure	$271	$50	$69	$132	$522
Newer Labs & Structure	$101	$13	$23	$2	$139
Underground Tanks	$31		$23	$144	$198
Controlled Yard	$99	$20	$24	$28	$170
D&D Planning	$23				$23
Characterization Surveys	$58		$7		$65
Final Surveys	$232		$29		$260
Planning, Training & Mobilization	$9				$9
Contractor Project Oversight	$167				$167
Owner Oversight & Licensing	$154				$154
NRC Verification Survey					$20
Total	**$1,364**	**$115**	**$258**	**$695**	**$2,452**
		25 % CONTINGENCY			**$613**
			GRAND TOTAL		**$3,065**

* The estimate for LLW disposal is based upon the assumption that the activated waste will be buried at the Barnwell, South Carolina site and all other radioactive waste will be buried at the Envirocare of Utah site.

1.2.3 Availability of Funds

Estimates of the costs of decommissioning of UVA USNRC licensed facility were provided in UVA's December, 1999 submittal to USNRC (Ref. 1.5). The University of Virginia is committed to providing the funding for decommissioning of the University of Virginia Reactor.

1.2.4 Program Quality Assurance

A Quality Assurance Project Plan (QAPP) will be developed to incorporate the applicable portions of 10 CFR 50, Appendix B. In addition, the QAPP will identify additional procedures and requirements that are applicable based on government and regulatory requirements, contractual commitments and supplemental quality standards.

An extensive quality assurance program will be carried on throughout the UVAR decommissioning effort to assure that work does not endanger public safety, and to assure the safety of the decommissioning staff.

Quality assurance efforts during the UVAR decommissioning period will include the following:

- Performing QA functions for procurement
- Qualifying suppliers
- Auditing all project activities
- Monitoring worker performance for compliance with work procedures
- Verifying compliance of radioactive shipments with appropriate procedures and regulations
- Performing dimensional, visual, nondestructive examinations or other required inspection services to assure compliance with work plans
- Maintaining auditable files on the QA audits
- Preparing a final report on overall performance on the UVAR Decommissioning Project with regard to the QA function

The QAPP will be issued and approved by UVA and it will be documented by written procedures and implemented throughout the decommissioning project in accordance with those procedures. The management of those organizations participating in the QAPP shall regularly review the status and adequacy of that part of the plan which they are implementing. All changes to the Plan shall be governed by measures commensurate with those applied to the original issue.

The Quality Assurance Project Plan will incorporate the following items.

1.2.4.1 Quality Assurance Responsibilities

The Quality Assurance organizations of the decommissioning contractor and UVA have the responsibility, authority and organizational freedom to:

- Identify quality problems.
- Take action to stop unsatisfactory or unsafe work and control further processing, delivery, installation or use of nonconforming items
- Initiate, recommend or provide solutions
- Verify implementation of solutions.

The decommissioning contractor has overall responsibility for the Quality Assurance (QA) Plan implementation and is responsible for verifying the effective execution of the plan.

1.2.4.2 Quality Requirements

Instrumentation Calibration

Field instruments and associated detectors shall be calibrated on a semi-annual basis using National Institute of Standards and Technology (NIST) traceable sources and appropriate calibration equipment. Laboratory instruments shall be calibrated on an annual basis.

Calibration labels showing instrument identification number, calibration date and calibration due date shall be attached to all field and laboratory instrumentation.

Instrumentation Response Testing

Functional checks (source check, battery check, high voltage check, etc.) will be performed daily on those instruments used on a daily basis, or when unusual readings are observed to verify proper performance. Instrument functional checks will also be performed prior to first use whenever instruments are repaired, cleaned or have the batteries replaced.

A performance study will be conducted for each type of instrument to determine the duration of the sampling period required to obtain a suitable LLD. The LLD should be a maximum of 50% of the release limits for contamination with an objective of less than 25% of the release limits.

Instrumentation Maintenance

Limited maintenance, such as changing Mylar windows, high voltage cables, etc., may be performed on-site by qualified personnel. Following the change of essential components for maintenance, limited calibration may be performed on-site by qualified personnel.

Instrument Record Keeping

Calibration records and maintenance records, or copies of these records, shall be maintained on-site where they will be available for review. The results of the daily instrument functional checks will be recorded on separate log sheets for each instrument and maintained on-site.

1.2.4.3 Sampling and Analysis Quality Control

Sample Collection

Direct surface beta-gamma measurements, removable contamination measurements, gamma exposure rates, soil sampling and any specialized measurements will be performed to provide data required to meet the guidance provided in 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use* (Ref. 1-5), NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 1-6), and NRC *Draft Regulatory Guide* DG-4006 (Ref. 1-7).

Sample QC

Quality Control (QC) samples will be obtained for minimum of 10% of all samples collected for radionuclide specific analysis. QC samples for direct measurements and smears are not required. The QC samples will be a combination of split, duplicate, blank, and/or spiked samples.

Sample Identification

Direct surface beta-gamma measurements, removable contamination samples, gamma exposure rates, and any specialized measurements will be identified as to location, type of measurement, specific instrument and probe used, sample time and date (as appropriate) and name of the person collecting the data.

Soil samples shall be identified with a unique sample number, sample location, survey grid designation, depth of sample, sample time and date as appropriate, and with the name of the person collecting the sample.

Sample Labeling

Removable contamination samples and soil samples shall be labeled to include all the information listed under sample identification.

Sample Chain-of-Custody

Sample chain-of-custody shall be initiated for those samples being sent off-site for analysis or transferred to another organization for analysis. A sample Chain-of-Custody Record will be generated which will document the sample identification and sample transfer, and will accompany the sample during shipping to the new custodian of the sample.

Sample Analysis

Vendor laboratories should be on a QA Approved Suppliers List for the decommissioning contractor or the University of Virginia for the type of analytical services being provided. The decommissioning contractor is responsible for ensuring that sample analysis specifications and laboratory capabilities will meet NRC requirements for data quality to release the site for unrestricted use and termination of license.

Sample Documentation

Sample identification information, sample Chain-of-Custody Records, sample analysis results, vendor laboratory qualification records, or copies of these records, shall be maintained on-site where they will be available for review.

1.2.4.4 Record Keeping

Measures shall be established to control the issuance of documents and changes to documents that prescribe activities affecting quality, such as procedures, drawings and specifications. These measures shall ensure that documents and changes to documents are reviewed for adequacy, approved for release by authorized personnel and distributed to and implemented at the location where the prescribed activity is performed.

Procedure Control

Procedures shall be controlled to ensure that current copies are provided to personnel performing the prescribed activities. Procedures shall be independently reviewed by a qualified person and shall be approved by a management member of the organization responsible for the prescribed activity. Significant changes to procedures shall be reviewed and approved in the same manner as the original.

Radioactive Shipment Package Documents

All documents related to a specific shipping package for radioactive material shall be controlled by appropriate procedures. All significant changes to such documents shall be similarly controlled.

Final Survey Documents

All documents related to the final survey documentation shall be controlled by appropriate procedures. All significant changes to such documents shall be similarly controlled. This documentation would normally include a Survey Plan, Survey Packages, Survey Results and Survey Report.

1.2.4.5 Handling, Storage and Shipping

Approved procedures shall be utilized to control the handling, storage and shipping of radioactive materials.

Radioactive Material Storage

Areas shall be provided for storage of radioactive material to ensure physical protection and control of the stored material. The handling, storage and shipment of radioactive material shall be controlled through the following requirements:

- Procedures shall be provided for handling, storage and shipping operations.
- Established safety requirements concerning the handling, storage and shipping of packages for radioactive material shall be followed.
- Shipments shall not be made unless all test, certifications, acceptances and final inspections have been completed.

Shipping and Packaging

Shipping and packaging documents for radioactive material shall be consistent with pertinent regulatory requirements.

1.2.4.6 Quality Assurance Records

Sufficient records shall be maintained to furnish evidence of activities important to safe decommissioning as required by code, standard, specification or project procedures. Records shall be identifiable, available and retrievable. The records shall be reviewed to ensure their completeness and ability to serve their intended function. Requirements shall be established concerning record collection, safekeeping, retention, maintenance, updating, location, storage, preservation, administration and assigned responsibility. Requirements shall be consistent with applicable regulations and the potential for impact on quality and radiation exposure to the workers and the public.

Typical records would include:

- Proposed Decommissioning Plan
- Procedures
- Reports
- Personnel qualification records
- Radiological and environmental site characterization records, including final site release records
- Dismantlement records
- Inspection, surveillance, audit and assessment records

Health and Safety Related Activities

Records that have a potential for impact on quality and radiation exposure to the workers and the public include the following:

- Work Permits
- Work Procedures
- Contamination Survey Report
- Airborne Survey Report
- Counting data or air samples and gamma spectrum analysis
- Instrument calibrations
- Source inventory and storage
- Radioactive material inventory and storage
- Shipment records
- Incidents and accidents
- Confined space entry permits
- Monitoring records for oxygen deficient explosive atmosphere

Personal Records

Typical records containing personal information that may impact quality and radiation exposure to the workers and the public are as follows:

- Bioassay analysis
- Respiratory protection qualifications (medial/clearance and fit test)
- Training records
- Visitor logs and exposure information

1.2.4.7 Audits

Audits shall be implemented to verify compliance with appropriate requirements of the Quality Assurance Plan and to determine the effectiveness of the plan. The audits shall be performed in accordance with written procedures or checklists by trained and qualified personnel not having direct responsibility in the areas being audited.

Audit Reports

Reports of the results of each audit shall be prepared. These reports shall include a description of the area audited, identification of the individual responsible for implementation of the audited provisions and for performance of the audit, and identification of discrepant areas. The audit report shall be distributed to the appropriate level of management and to those individuals responsible for implementation of audited provisions.

Audit Corrective Action

Measures shall be established to ensure that discrepancies identified by audits are resolved. These measures shall include notification of the manager responsible for the discrepancy and verification of satisfactory resolution. Discrepancies shall be resolved by the manager responsible for the discrepancy. Higher levels of management shall resolve disputed discrepancies.

Follow-up action, including re-audit of deficient areas, shall be taken as indicated.

REFERENCES FOR SECTION 1

1-1 NUREG- 1537 Rev. 0, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors".

1-2 Amendment No. 25 to Facility License No. R-66 (UVA Reactor) — University of Virginia, Anticipated Issue in early year 2000 by the USNRC, UVA request dated August 16, 1999.

1-3 The University of Virginia, *Decommissioning Cost Estimate UVA Reactor Facility, Charlottesville, Virginia*, Revision 0, January 2000, prepared by GTS Duratek.

1-4 Xtreme PM℠, Integrated Project Management System, GTS Duratek and Merrimac.

1-5 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use*.

1-6 NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*.

1-7 Draft Regulatory Guide DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination*, August 1998.

2.0 DECOMMISSIONING ACTIVITIES

The decommissioning alternative selected for the UVA Reactor is the removal of the facility from service and reduction of the radioactivity to a level that will permit release of the property for unrestricted use and termination of the license. The facility will be surveyed and left in place. Some areas will be refurbished, such as backfilling of the pool and tank excavation areas.

2.1 DECOMMISSIONING ACTIVITIES

The objective of UVAR Decommissioning is the regulatory release of the UVAR and adjacent contiguous facility site environs, identified on Figure 1-4, to unrestricted use. On this basis the safe storage (SAFSTOR) or entombment (ENTOMB) decommissioning options were considered inappropriate to UVA's future plans.

SAFSTOR poses essentially the same potential risks and environmental impacts as the proposed project, but for a much greater period of time. This alternative would necessitate continued surveillance and maintenance of the UVAR over a substantial time period during which the risk of environmental contamination would continue to exist. Moreover, development of the land around the UVAR site over the next few years may increase the local population density and increase the potential for public exposure.

ENTOMB would necessitate continued surveillance and maintenance of the UVAR over a substantial time period. During this period, the risk of environmental contamination would continue to exist. Moreover, development of the land around the UVAR site over the next few years may increase the local population density and increase potential for public exposure.

DECON is the decommissioning option chosen by U.Va.. To the extent possible, decontamination of facility equipment and structural components will be conducted so as to minimize radioactive waste. Structural portions of the building and surrounding soils and materials found to be radiologically contaminated and/or activated shall be remediated, decontaminated, sectioned and removed or processed, as necessary. This would be followed by an extensive and comprehensive final radiation and contamination survey demonstrating that the UVAR meets the NRC criteria for release to unrestricted use. The results of this final survey will be documented in a report to be submitted to the USNRC in support of a request that the site be released to unrestricted use and the reactor license terminated.

2.2 Facility Radiological Status

2.2.1 Facility Operating History

Startup: June, 1960

Shutdown: Midnight, June 30, 1998; USNRC Utilization Facility License. #R-66 anticipated to be limited to a Possession-Only-Amendment (POA) status in early year 2000 (see Ref. 2-1).

The UVA Reactor was constructed by UVA to provide for the training of Nuclear Engineering students and for research by all Departments of Engineering and the Departments of Physics, Chemistry, Biology, and Medicine. The integrated power generated during operation of the UVA Reactor is estimated at 2,559 MW-days.

2.2.2 Current Radiological Status of the Facility

2.2.2.1 General

Routine radiological surveys show that the radiation levels and contamination levels measured at the UVAR have consistently been low. A radiological study completed in September 1999, and summarized in Appendix A, confirmed that only minor quantities of residual radioactivity or radioactive contamination are present. The information indicates that the radioactive portions of the facility are primarily confined to the reactor internals and reactor pool.

Estimates of the radioactivity inventory can be determined by considering the constituent elements of the material in question and calculating the duration of exposure to the neutron flux and the energies of the incident neutrons. Direct measurements, however, are generally more reliable and will be used during actual removal and/or dismantlement of components. This information will further define the basis for specifying the necessary safety measures and procedures for the various dismantling, removal, decontamination, waste packaging and storage operations so that exposure to personnel is maintained ALARA.

2.2.2.2 Principal Radioactive Components

This section is based upon process knowledge and direct measurements. The most highly radioactive components to be handled and processed during UVAR Decommissioning which may range over $\approx$ 5 R/hr at the surface are:

- Two EPRI experiment stands (Al) reading about 19 R/hr.
- Mineral Irradiation Facility (MIF) shield reading about 13 R/hr.
- An old control rod (stored in the pool) reading about 10 R/hr.
- Three tangential beamport targets reading 6 to 8 R/hr.
- Hydraulic Rabbit (Al) about 25' long reading about 6 R/hr.

2.2.2.3 Radionuclides

The radionuclides known to be present, or possibly present in detectable levels within the UVAR, are listed in Table 2-1.

2.3 Decommissioning Tasks

2.3.1 Activities and Tasks

2.3.1.1 Preparation of the UVAR for Decommissioning

2.3.1.1.1 Characterization Surveys

As part of Decommissioning Project planning actions, studies have been conducted to determine the type, quantity, condition and location of radioactive and/or hazardous materials which are, or may be, present in the UVAR and surrounding areas. A comprehensive radiological survey of the UVAR was completed in September 1999 by a contractor, GTS Duratek. Data and results from these surveys are provided in this document as Appendix A: *Summary of Characterization Results*.

2.3.1.1.2 General Cleanup of UVAR and Adjacent Controlled Yard Areas

In preparation for decommissioning activities, non-reactor related equipment and materials situated throughout the Reactor Facility have been collected, surveyed, packaged and appropriately dispositioned in accordance with established procedures. Examples of items which have been/or will be processed and removed from the UVAR during these efforts are shield blocks around the beam ports and lead shielding used in the beam port and reactor room areas.

2.3.1.1.3 Decontamination of the Facility

This Decommissioning Plan pertains to the dismantling of the reactor and associated systems in a safe manner and in accordance with ALARA principles, and the decontamination and survey of the entire UVAR facility. Views of the UVA reactor are shown in Figure 2-1 and Figure 2-2.

Table 2-1 List of Expected Radionuclides

Nuclide	Half-Life (yr)	Decay Mode/Major Radiations	Notes
^{14}C	5,730	β^-/β^-	AP; from n-activation of graphite reflector structure
^{54}Mn	0.86	ε/λ	AP; short-lived specie; from n-activation of SS hardware
^{55}Fe	2.73	$\varepsilon/$	AP; from n-activation of SS hardware
^{60}Co	5.27	$\beta^-/\beta^-, \lambda$	AP; from n-activation of SS hardware; expected to be predominant AP specie present
^{59}Ni	76,000	ε/λ	AP; from n-activation of SS hardware
^{63}Ni	100	β^-/β^-	AP; from n-activation of SS hardware. Also from liquid solution in research project
^{90}Sr	29.1	β^-/β^-	FP; probable FP constituent; activity expected to be proportional to that of ^{137}Cs
^{94}Nb	20,000	$\beta^-/\beta^-, \lambda$	AP; unlikely AP inventory constituent; possible from n-activation of SS hardware, <u>if</u> Nb impurities are present
^{99}Tc	213,000	β^-/β^-	FP, and minor AP inventory constituent; possible from n-activation of SS hardware, if Mo impurities are present. Also from acidic liquid solution in research project
^{125}Sb	2.76	$\beta^-/\beta^-, \lambda$	FP; relatively short-lived specie
^{134}Cs	2.07	$\beta^-/\beta^-, \lambda$	FP; minor FP inventory constituent
^{137}Cs	30.17	$\beta^-/\beta^-, \lambda$	FP: expected to be predominant FP specie present
^{152}Eu	13.48	$\beta^-, \beta^+, \varepsilon/\beta^-, \beta^+, \lambda$	FP, and minor AP inventory constituent; possible from n-activation of concrete, <u>if</u> Eu impurities exist in biological shield structure
^{226}Ra	1,600	$\alpha/\alpha, \lambda$	Natural background source, sealed & liquid sources
^{nat}U		$\alpha/\alpha, \lambda$	Natural background sources, sealed and unsealed sources
$^{233/234}U$	>159,200	$\alpha/\alpha, \lambda$	Natural and failed fuel sources, trace quantities only anticipated
^{241}Pu	14.4	$\beta^-/\beta, \alpha, \lambda$	Failed fuel source, trace quantities only anticipated, sealed sources
^{241}Am	432	$\alpha/\alpha, \lambda$	Research project
$^{235/238}U$	>7.0E+8	$\alpha/\alpha, \lambda$	SNM material used or stored at facility

Symbols/Abbreviations:
α = Alpha Particle
β^- = Beta Particle
β^+ = Positron
ε = Electron Capture
λ = Gamma-Ray
AP = Activation Product
FP = Fission Product

Radionuclide Half-Life values and Decay Mode information used above are taken from Ref. 2-2.

The list of expected radionuclides provided above is based on the assumption that reactor operation resulted in neutron activation of reactor core components and other integral hardware or structural members situated adjacent to, or in close proximity to, the reactor core. Specific items to be considered exposed to neutron activation include materials composed of aluminum, steel, stainless-steel, graphite, cadmium, lead, concrete and possibly others. Based on prior studies and experience gained in similar research reactor decommissioning projects, reactor core/pool structural configurations, and material composition of exposed pool structures, neutron activation of materials beyond the concrete liner/biological shield structure (i.e., ‘into surrounding soil volumes’) is not expected for this reactor.

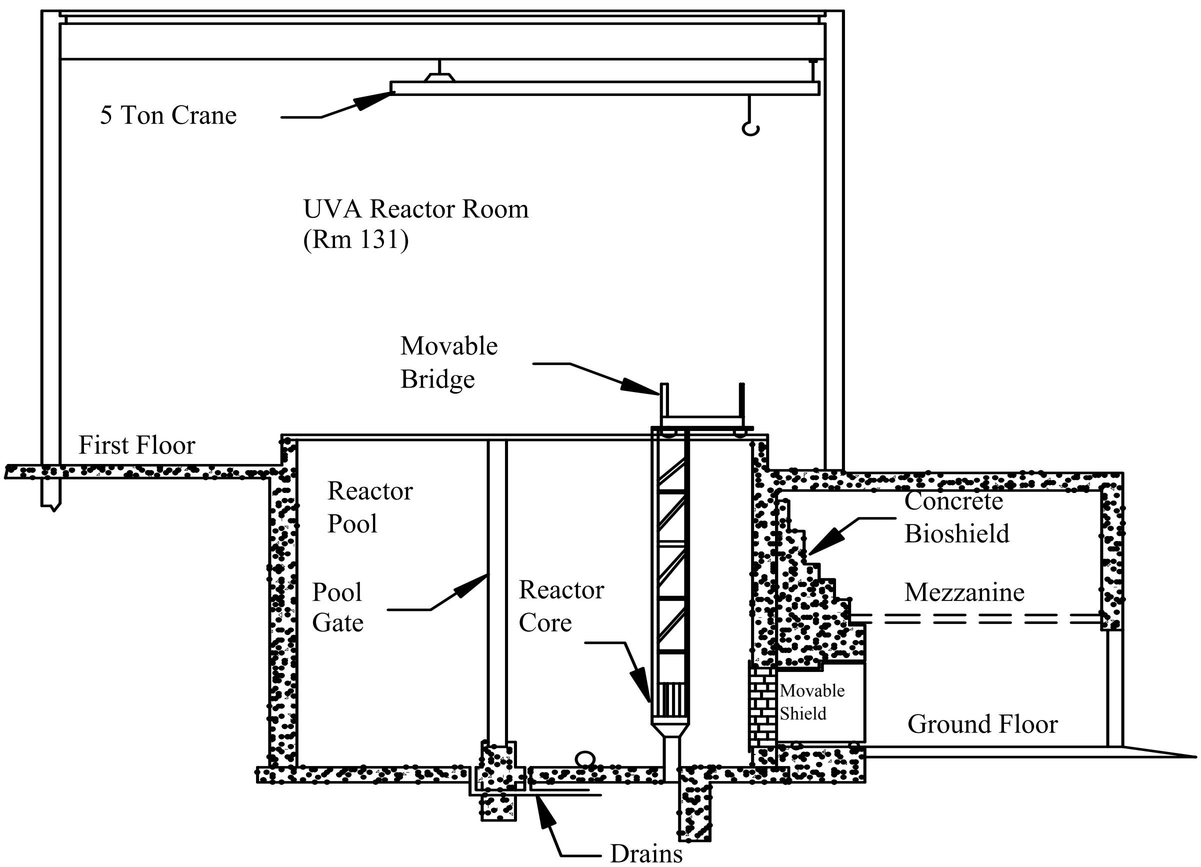


Figure 2-1 UVA Reactor Elevation View

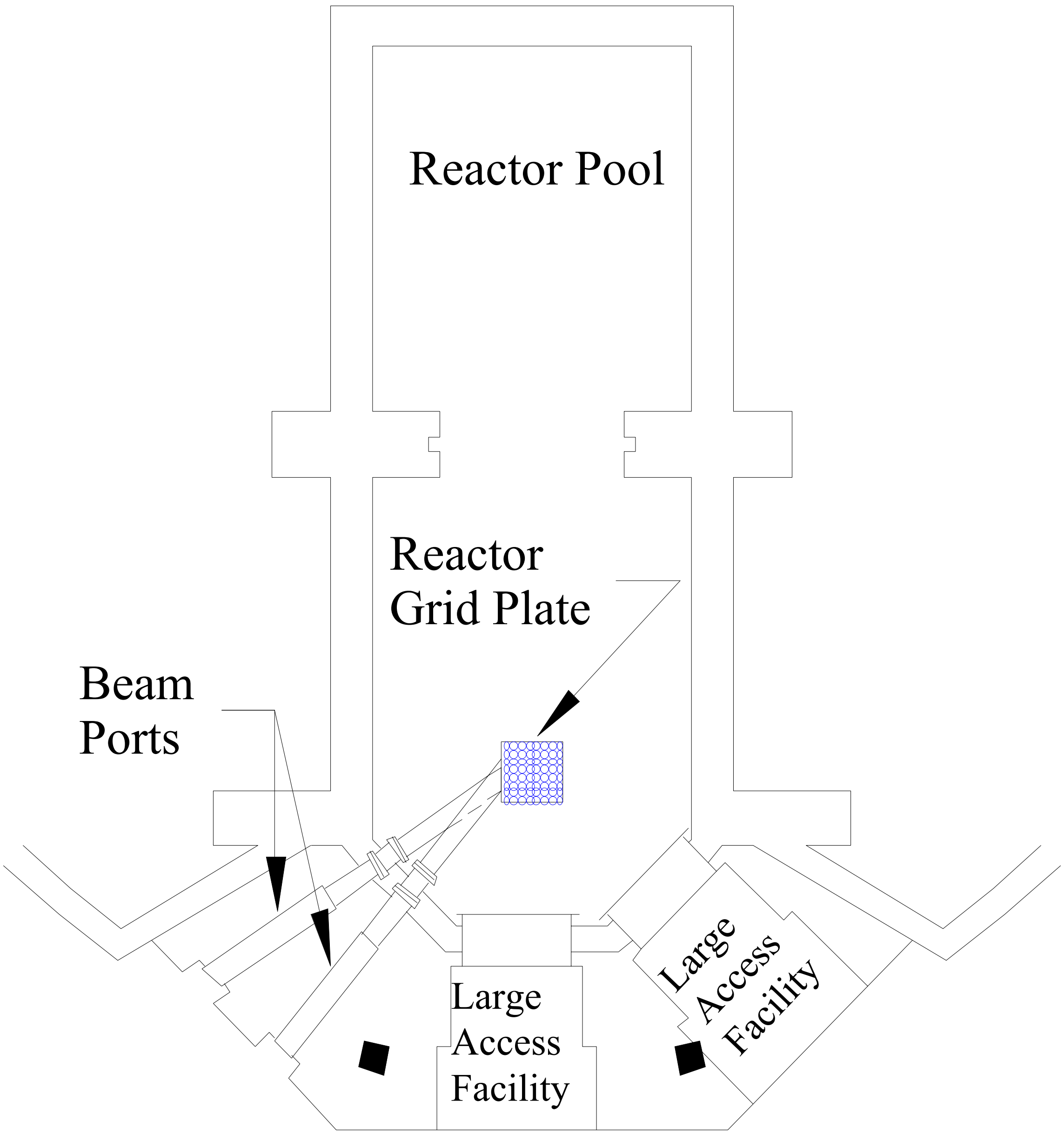


Figure 2-2 UVA Pool and Reactor Cross Section View

2.3.1.1.3.1 Reactor Confinement Structure

● All reactor confinement structure, equipment and materials will be surveyed and designated as contaminated or uncontaminated.

● Uncontaminated equipment and materials will be released for unrestricted use or disposal as clean waste.

● Contaminated equipment will be decontaminated and handled as other uncontaminated material or removed and packaged for processing and direct disposal as radioactive waste.

● Control room and equipment storage rooms will be demolished, processed and removed.

● Reactor ventilation system will be removed and packaged for processing and disposal or direct disposal as radioactive waste.

● Concrete floors will be decontaminated by removing a portion of the upper concrete surface, as necessary. Tubes and drains will be surveyed and decontaminated as required.

● Building off-gas stack will be surveyed and released for disposal as salvage, or disposal as clean waste.

● The Polar Crane will be utilized during the decommissioning activities. It will be surveyed, decontaminated in place as required and left intact and in operating condition.

2.3.1.1.3.2 Reactor and Pool

● Reactor components and activated pool hardware will be removed in hardware liners for disposal as LLRW. A cask will be brought in and loaded with the hardware liners and shipped to the Barnwell, South Carolina LLW facility for disposal. The removal of these items can take place with the pool either filled or drained.

● When no longer useful as a radiological shield, the reactor pool water will be surveyed and discharged.

● The dismantling of the reactor support structure and pool will proceed after installation of a confinement barrier in the reactor room with a dedicated ventilation system to prevent the spread of airborne contaminants.

- The beam port extension tubes (nosepieces) will be removed.

- All other hardware and debris present in the pool will be removed and similarly processed.

- Piping embedded in the concrete pool walls and floors will be surveyed and decontaminated, as necessary, and left in place if clean.

- Surface and coring samples of the pool concrete walls will be performed to determine the extent of the contaminated areas. Contaminated material will be removed and packaged. The structural integrity of the pool will not be compromised as a result of limited removal material.

- Required sampling and analysis of surrounding soils will be done by coring, and repair after sampling. Shoring and covering of the pool will provide industrial-protection until the final confirmatory release surveys have been performed.

- The portion of the pool walls that extend 3-feet above the reactor room floor slab will be cut off and may be handled as clean waste.

- The remaining tasks are dismantlement of the confinement barrier, removal of residual surface contamination in the rooms, and final confirmatory release surveys. The packaged waste is to be shipped to a licensed processing or disposal facility.

2.3.1.1.3.3 Remaining Rooms and Structure

- Reactor-associated equipment and materials will be surveyed and designated as contaminated or uncontaminated.

- Contaminated room surfaces will be decontaminated.

- Uncontaminated equipment and materials will be released for unrestricted use or disposal as clean waste.

- Contaminated equipment will be decontaminated and handled either as uncontaminated material, or removed and packaged for processing and direct disposal as radioactive waste. This includes process equipment in the demineralizer room, process equipment in the heat exchanger room, contaminated hoods in laboratory rooms, process equipment in the beam port facility and equipment in the hot cell facility.

● The 7,000 curies of Co-60 stored in a licensed cask in the facility's hot cell will be relocated prior to the end of decommissioning.

2.3.1.1.3.4 Underground Tanks and Vaults

● All underground tank and vault process piping and equipment will be removed, surveyed and designated as contaminated or uncontaminated.

● Uncontaminated piping, equipment and materials will be released for unrestricted use or disposal as clean waste.

● Contaminated piping and equipment will be decontaminated and handled as other uncontaminated material, or removed and packaged for processing and direct disposal as radioactive waste.

● The buried piping from the building will be surveyed and decontaminated if necessary.

● The soil over the top of these tanks will be excavated, surveyed, sampled and piled for later use in backfilling the hole.

● The tanks will be removed, cut to size and packaged for processing and direct disposal as radioactive waste.

2.3.1.1.3.5 Outdoor Areas, Drains & Sewers

● No remediation is anticipated for the sanitary and storm sewers, the pond, the pond discharge creek, paved areas and unpaved areas at the UVAR site.

2.3.1.2 Dismantling Sequence

Dismantling will occur sequentially by the detailed schedule shown in Section 2.3.2. Items removed will be grouped as follows:

Group 1 Equipment which does not have induced radioactivity but which may have surface contamination.

Group 2 Core components and other components which have induced radioactivity, including pool concrete which has been neutron activated.

Group 3 Reactor support systems, equipment and materials associated with laboratory and research facilities.

Group 4 Equipment, tools and systems which become contaminated during decommissioning operations.

Components and equipment in the four groups are identified in Table 2-2, Table 2-3, Table 2-4 and Table 2-5.

The control rods in the UVAR pool are expected to have the highest levels of induced radioactivity. The control rods and other Group 2 items will be hoisted from the pool within shielded containers which will have been prepared to accept the items. Additional shielding will be provided for worker protection if necessary.

After pool components, equipment and parts listed in Table 2-2 and Table 2-3 have been removed, a confinement barrier will be installed. The purpose of this barrier is to contain airborne contaminants generated during pool decontamination, and to prevent their spread in the Reactor Room and the surrounding areas.

A confinement barrier will be erected which will surround the reactor pool. An independent, localized, ventilation system to ensure a negative pressure with respect to the Reactor Room and provide high efficiency filtration on the exhausted air will be associated with the enclosure.

Table 2-2 Components with Potential Surface Contamination - Group 1

Reactor Systems	demineralizer resin, tanks, pipe loop and floor drains
	heat exchanger, heat exchanger piping loop
	pneumatic and hydraulic rabbit transfer systems
	reactor bridge structure
	reactor pool gate
Laboratory Areas	fume hoods, sink drains, floor drains, counter tops and HVAC
Beam Access Facilities	thermal access facility, large access facility, beam port facility
Hot Cell	hot cell systems, drain piping and buried filter and tanks
Liquid Waste System	plastic waste tanks, buried waste tanks, piping and holding pond

Table 2-3 Components with Induced Radioactivity - Group 2

Mineral Irradiation Facility (MIF)

Control rods
Grid plate
Grid plate plugs
Rotating Irradiation Facility (RIF)
EPRI experiment stand
Neutron beamport nosepieces and targets
Fasteners and connectors
Hydraulic and pneumatic transfer rabbits and system tips
Graphite elements
Hot Thimbles
Other experimental facilities

Table 2-4 Contaminated and Activated Reactor Pool Components - Group 3

Contaminated pool concrete
Activated pool concrete
Beamport activated concrete
Contaminated bioshield concrete

Table 2-5 Equipment Used In Decommissioning Operations - Group 4

General ventilation system
Temporary localized ventilation system
Confinement barrier

Contaminated tools and equipment
Contaminated clothing

When necessary, the Reactor Room will be maintained at a slightly negative pressure with respect to the surrounding areas but less than the pressure differential maintained between the confinement barrier and the Reactor Room. This will ensure that the air will travel from the non-contaminated area to the increasingly contaminated areas.

The contaminated and activated pool/biological shield concrete will be removed. To minimize dust dispersal, a localized HEPA vacuum system may be used in the area where concrete is being demolished. Contaminated concrete will be removed by surface removal equipment from the upper surfaces down to the floor. Activated concrete will be removed a section at a time and shoring supports will be placed in the cavity formed as needed, before proceeding with the next section. The embedded piping that passes from the pool to the heat exchanger and the demineralizer system will be surveyed and decontaminated if necessary.

At the completion of contaminated and activated concrete removal, dose rate measurements will be made to determine if all necessary portions have been removed. Post-remediation surveys may include concrete and soil coring sampling and analysis. As the removal of activated material proceeds, the radioactive material will be packaged for shipment and disposal.

There are two potential radiological safety concerns during performance of this task: 1) external exposure from the activated components in the pool, and 2) inhalation of airborne material. To minimize the risk, during occupancy, the work areas will be monitored frequently and radiation levels will be monitored continuously, to determine sudden changes in the radiological conditions.

Upon completion of dismantlement tasks in the reactor pool, the confinement barrier will be dismantled and the plastic sheets compacted and packaged. Surface contamination will be removed from contaminated portions of the ventilation system and they will then be packaged for disposal. The reactor room will then be cleared and all surface contamination removed. Following remediation and surveys the pool pit will be backfilled and capped with a concrete slab.

All process equipment in the waste tank vault and hot cell tank vault will be removed. The piping that passes underground to the reactor building and to the pond will be surveyed and decontaminated, if necessary. The soil over the top of the buried waste tanks and hot cell tanks will be excavated, surveyed, sampled and piled for later use in backfilling the hole. The tanks will be removed, cut to size and packaged for processing and disposal or direct disposal as radioactive waste. Following remediation and surveys the buried tank area will be backfilled to grade.

2.3.1.3 Surveys

Following decontamination and remediation activities of the reactor, a final radiation survey of each of the reactor rooms and other applicable locations covering the entire UVAR Facility will be performed and documented.

2.3.2 Schedule

The project schedule is presented as Figure 2-3. This schedule was developed using Xtreme PM℠ (Ref. 2-3). The scheduled time from regulatory approval of the Decommissioning Plan to submittal for release of the site to unrestricted use is 13 months. Based on project schedule information documented here in Figure 2-3, UVA estimates that a formal request for termination of Facility License No. R-66 will be submitted to the USNRC approximately twelve months after the approval of the decommissioning plan is received from the USNRC. The UVAR Decommissioning Project is currently scheduled to run from August 2000 to August 2001. Changes to the schedule may be made at UVA's discretion as a result of resource allocation, availability of a radioactive waste burial site, interference with ongoing UVA activities, ALARA considerations, further characterization measurements and/or temporary on- site radioactive waste storage operations.

2.4 Decommissioning Organization and Responsibilities

UVA is committed to, and retains ultimate responsibility for full compliance with the existing USNRC reactor licenses and the applicable regulatory requirements during decommissioning. University policies and goals will be followed to ensure high standards of performance in accomplishing the decommissioning tasks.

The Reactor Decommissioning Committee will monitor decommissioning operations to ensure they are being performed safely and according to federal, state, and local regulatory requirements (NRC, EPA, DOT, etc.). The Reactor Decommissioning Committee will review major decommissioning activities dealing with radioactive material and radiological controls. In addition, the Reactor Decommissioning Committee and/or the Reactor Director will review and approve changes to the Decommissioning Plan that do not require prior NRC approval.

The planned organization for the UVAR Decommissioning as shown in Figure 2-4 will be maintained, however individuals performing the functions may vary over the project duration. Specialized contractors may be utilized under the direction of the UVA Reactor Facility Director, when necessary and appropriate.

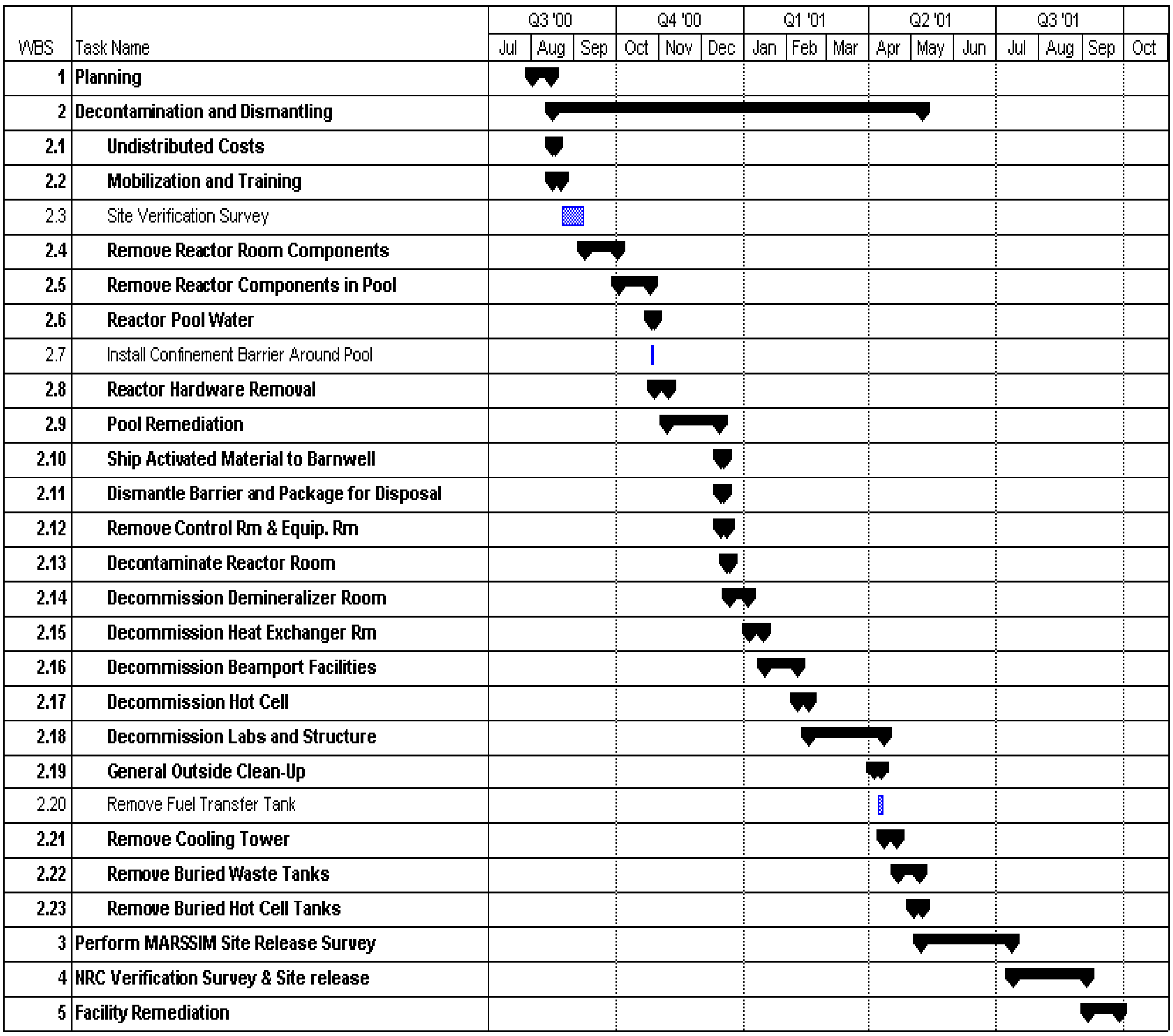
2.4.1 Contractor Assistance

UVA management will select a qualified contractor to perform the UVAR Decommissioning Project. The team will consist of UVA personnel and the selected contractor. UVA will be in charge of overall project management; a decommissioning operations contractor (DOC) will manage the physical decommissioning work, provide Health Physics support, radiation surveys, and waste packaging, processing, and shipping.

The Xtreme PM℠ system (Ref. 2-3) which was used to develop the project estimate and schedule can be used to assist the project team in effectively managing the decommissioning project. Cost, schedule, worker exposure, waste, survey results, training, equipment use, consumables, etc. can be tracked using Xtreme PM℠. The system's advanced estimating tools can be used to generate various project scenarios to evaluate impacts from schedule changes, waste disposal options, decontamination techniques, outsourcing, etc.

Contractors and subcontractors performing work under this Decommissioning Plan will be required to comply with applicable UVA policies and procedures.

Figure 2-3 UVAR Decommissioning Schedule



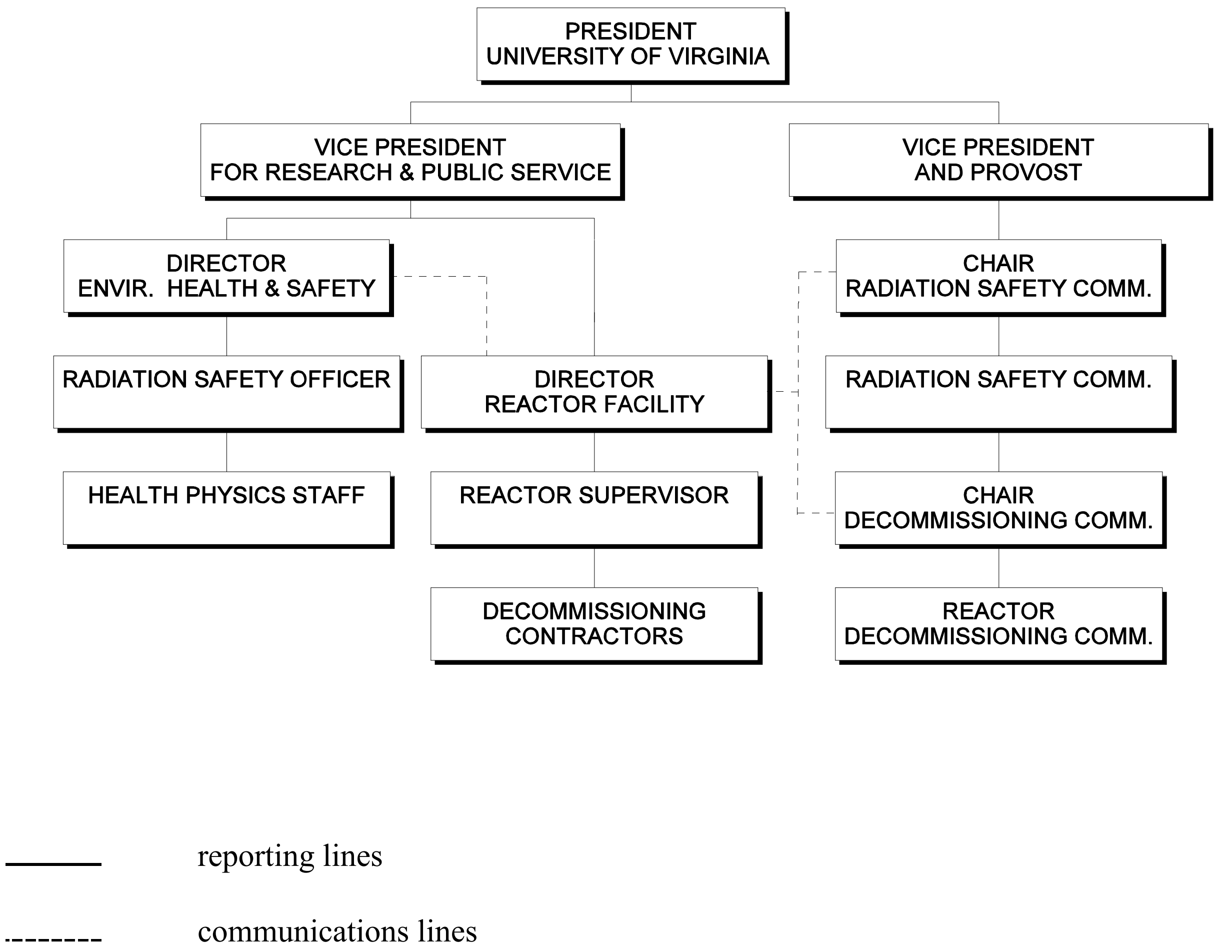


Figure 2-4 UVAR Decommissioning Organization

Key Positions

2.4.2 Reactor Facility Director

The Reactor Facility Director has the overall responsibility for successful completion of the Project. The UVA Reactor Facility Director functions include:

- Controlling and maintaining safety during decommissioning activities and protecting of the environment
- Determining UVA project staffing and organization
- Assuring performance to cost and schedule
- Reporting of performance
- Approving minor changes to the decommissioning plan and procedures (which do not change the original intent and do not involve an unreviewed safety question)
- Approving subcontracts
- Approving budgets and schedules
- Oversight and coordination of UVA functional groups and decommissioning contractors
- Ensuring that the conduct of decommissioning activities complies with applicable regulations and is in accordance with UVA licenses.

The minimum qualifications for the UVA Reactor Director are:

- A four-year degree in engineering or natural science
- Five years of management experience in the nuclear industry
- Familiarity with the UVA Reactor Facility
- Appropriate training in radiation protection, nuclear safety, hazardous communication and industrial safety.

2.4.3 Reactor Supervisor

The functions of the UVA Reactor Supervisor include:

- Maintaining the UVAR in a safe and proper condition during the evolution of Decommissioning Project activities, in accordance with the requirements set forth in the applicable USNRC facility licenses
- Review of plans and procedures
- Providing engineering support for the decommissioning activities

The minimum qualifications for this position are:

- A four-year degree in Engineering or Natural Science

- Five years experience in a research reactor facility environment

- Substantial knowledge of the UVAR and associated systems

2.4.4 Radiation Safety Officer

The Radiation Safety Officer is responsible for providing radiological support in the decommissioning of the UVAR. This function ensures that the activities involving potential radiological exposure are conducted in compliance with the applicable licenses, Federal and State regulations and UVA procedures. The position includes responsibility for maintaining the UVAR surveillance and monitoring program and for HP radiological protection procedures.

The minimum qualifications for this position are:

- A four-year degree in Health Physics or a related field
- Three years supervisory experience in Health Physics
- Five years operational experience related to radiation safety

2.5 Training Program

Individuals (employees, contractors and visitors) who require access to the work areas or a radiologically restricted area will receive training commensurate with the potential hazards to which they may be exposed.

Radiation protection training will be provided to personnel who will be performing remediation work in radiological areas or handling radioactive materials. The training will ensure that decommissioning project personnel have sufficient knowledge to perform work activities in accordance with the requirements of the radiation protection program and accomplish ALARA goals and objectives. The principle objective of the training program is to ensure personnel understand the responsibilities and the required techniques for safe handling of radioactive materials and for minimizing exposure to radiation.

Records of training will be maintained which will include trainees names, dates of training, type of training, test results, authorization for protective equipment use, and instructor's name. Radiation protection training provides the necessary information for workers to implement sound radiation protection practices. The following are examples of the training programs applicable to remediation activities.

2.5.1 General Site Training

A general training program designed to provide orientation to project personnel and meet the requirements of 10 CFR Part 19 will be implemented. General Site Training (GST) will be required for all personnel assigned on a regular basis to the remediation project. This training will include:

- Project orientation/access control
- Introduction to radiation protection
- Quality assurance
- Industrial safety
- Emergency procedures

2.5.2 Radiation Worker Training

Radiation Worker Training (RWT) will be required for remediation project personnel working in restricted areas and will be commensurate with the duties and responsibilities being performed. Personnel completing RWT are required to pass a written examination on the material presented. Completion of this training qualifies an individual for unescorted access to radiologically controlled areas. RWT will include the following topics:

- Fundamentals of radiation
- Biological effects of radiation
- External radiation exposure limits and controls
- Internal radiation limits and controls
- Contamination limits and controls
- Management and control of radioactive waste, including waste minimization practices
- Response to emergencies
- Worker rights and responsibilities.

In addition to a presentation of the topics identified above, participants in RWT are required to participate in the following demonstrations:

- The proper procedures for donning and removing a complete set of protective clothing (excluding respiratory protection equipment)
- The ability to read and interpret self-reading and/or electronic dosimeters
- The proper procedures for entering and exiting a contaminated area, including use of proper frisking techniques
- An understanding of the use of an Radiation Work Permit (RWP) by working within the requirements of a given RWP.

Personnel who have documented equivalent RWT from another site may be waived from taking training except for training on UVA administrative limits and emergency response, and will be required to pass the written examination and demonstration exercises.

2.5.3 Respiratory Protection Training

Personnel whose work assignments require the use of respiratory protection devices will receive respiratory protection training in the devices and techniques that they will be required to use. The training program will follow the requirements of 10 CFR 20 Subpart H (Ref. 2-4), Regulatory Guide 8.15 (Ref. 2-5), NUREG 0041 (Ref. 2-6) and 29 CFR 1910.134 (Ref. 2-7). Training will consist of a lecture session and a simulated work session. Personnel who have documented equivalent respiratory protection training may be waived from this training.

2.6 Decontamination and Decommissioning Documents and Guides

Health Physics, Industrial Health criteria and other standards that guide the activities described in this Decommissioning Plan are discussed in Section 3.1, Radiation Protection, Section 3.2, Radioactive Waste Management, Section 3.3, General Industrial Safety Program and Section 3.4 Radiological Accident Analysis. Relevant documents and guides used are noted therein.

2.7 Facility Release Criteria

The proposed decommissioning alternative that has been presented in this Decommissioning Plan does not necessitate the major dismantlement of the UVAR Facility building. The results of the site and facility radiological characterization have indicated that the building structures may be directly releasable without need for extensive decontamination.

This section provides the specific criteria for release of the UVAR Facility. The Final Release survey will use the Derived Concentration Guideline Levels (DCGL's) developed from the characterization survey data (Ref. 2-8) and the current NRC guidance for license termination in Subpart E, *Radiological Criteria for License Termination*, of 10 CFR Part 20, *Standards of Protection Against Radiation* (Ref. 2-9). Subpart E, 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use* (Ref. 2-10), allows termination of a license and release of a site for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent to an average member of a critical group that does not exceed 25 millirem (0.25 millisevert) per year and the residual radioactivity has been reduced to levels that are as low as is reasonably achievable (ALARA). The current NRC guidance for acceptable license termination screening values (meeting the 10 CFR 20.1402 criteria) of common radionuclides for building surface contamination is presented in *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for Licence Termination,* (Ref. 2-11). The DCGL's for soil areas were developed using the regulatory positions on dose modeling in *Draft Regulatory Guide DG-4006* (Ref. 2-12).

Upon completion of the decontamination and remediation activities (e.g. see Section 2.3), a final radiation and radiological contamination survey of the UVAR Facility will be performed using the method described in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 2-13). In addition, NRC DG-4006 will be used for additional specific guidance on acceptable values for use in the MARSSIM method, how to use the MARSSIM method in a way that is consistent with the dose modeling, how to use the MARSSIM method to meet NRC's regulations, and how to extend or supplement the MARSSIM method to address subsurface residual radioactivity. The results of the survey(s) will be summarized in a report which will be submitted to NRC, as required by the U.S. Nuclear Regulatory Commission NUREG 1537 (Ref. 2-14), in support of a license termination request.

Removable surface contamination will be eliminated, where possible, by wiping or other proven decontamination methods. Release criteria for fixed and smearable residual radioactivity for beta-gamma emitters will be based upon the relative concentrations of isotopes on the material and their respective release criteria if more than one category of nuclide for beta-gamma emitters applies from Table 2-6.

If it is impractical or not possible to satisfy release criteria (or conclusively demonstrate that they have been met), the location/item will be treated as radioactively contaminated and dispositioned as low-level waste.

Table 2-6 License Termination Screening Values for Building Surface Contamination

Radionuclide	Symbol	Acceptable screening levels[1] for unrestricted release (dpm/100 cm^2)[2]
Hydrogen-3 (Tritium)	^{3}H	1.2E+08
Carbon-14	^{14}C	3.7E+6
Sodium-22	^{22}Na	9.5E+03
Sulfur-35	^{35}S	1.3E+07
Chlorine-36	^{36}Cl	6.0E+05
Manganese-54	^{54}Mn	3.2E+04
Iron-55	^{55}Fe	4.5E+06
Cobalt-60	^{60}Co	7.1E+03
Nickel-63	^{63}Ni	1.8E+06
Strontium-90	^{90}Sr	8.7E+03
Technetium-99	^{99}Tc	1.3E+06
Iodine-129	^{129}I	3.5E+04
Cesium-137	^{137}Cs	2.8E+04
Iridium-192	^{192}Ir	7.4E+04

[1] Screening levels are based on the assumption that the fraction of removable surface contamination is equal to 0.1.

[2] Units are disintegrations per minute per 100 square centimeters (dpm/100 cm^2). 1 dpm is equivalent to 0.0167 becquerel (Bq). The screening values represent surface concentrations of individual radionuclides that would be deemed in compliance with the 0.25 mSv/yr (25 mrem/yr) unrestricted release dose limit in 10 CFR 20.1402. For radionuclides in a mixture, the "sum of fractions" rule applies; see 10 CFR Part 20, Appendix B, Note 4. NRC Draft Guidance DG-4006 for provides further information on application of the values in this table.

REFERENCES FOR SECTION 2

2-1 Amendment No. 25 to Facility License No. R-66 (UVA Reactor) — University of Virginia, Anticipated Issue in early year 2000 by the USNRC, UVA request dated August 16, 1999.

2-2 *The Health Physics and Radiological Health Handbook*, Revised Edition 1992, Editor by B. Shleien.

2-3 Xtreme PM℠, Integrated Project Management System, GTS Duratek and Merrimac.

2-4 10 CFR 20 Subpart H, *Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas*.

2-5 Regulatory Guide 8.15, *Acceptable Programs for Respiratory Protection*; Revision 1, October, 1999

2-6 NUREG 0041, *Manual of Respiratory Protection Against Airborne Radioactive Materials*

2-7 29 CFR 1910.134, *Respiratory Protection*

2-8 UVAR Characterization Survey Report

2-9 10 CFR 20 Subpart E, *Radiological Criteria for License Termination*

2-10 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use*

2-11 *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for Licence Termination,* the Federal Register (63 FR 64132, 11/18/98)

2-12 Draft Regulatory Guide DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination*, August 1998

2-13 NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*

2-14 NUREG 1537, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors*, February 1996.

3.0 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

3.1 Radiation Protection

3.1.1 Ensuring As Low As Reasonably Achievable (ALARA) Radiation Exposures

Decommissioning activities at the UVA Reactor Facility involving the use and handling of radioactive materials will be conducted in a manner such that radiation exposure will be maintained As Low As Reasonably Achievable (ALARA), taking into account the current state of technology and economics of improvements in relation to the benefits.

ALARA Program

The UVA practice during this project will be as follows:

- A documented ALARA evaluation will be required for specific tasks if a Project HP determines that 5% of the applicable dose limits for the following may be exceeded:
  - Total Effective Dose Equivalent (TEDE)
  - The sum of the Deep-Dose Equivalent (DDE) and the Committed Dose Equivalent (CDE) to any individual organ or tissue other than the lens of the eye
  - Eye Dose Equivalent (EDE)
  - Shallow-Dose Equivalent (SDE)
- A documented ALARA evaluation will be required if a Project HP determines that UVAR effluent averaged over one year is expected to exceed 20% of applicable concentration in 10 CFR 20, Appendix B, Table 2, Columns 1 and 2.

Decommissioning Project management positions responsible for radiation protection and maintaining exposures ALARA during decommissioning include the Reactor Facility Director and Radiation Safety Officer.

Methods for Occupational Exposure Reduction

Various methods will be utilized during the Decommissioning Project work to ensure that occupational exposure to radioactive materials is kept ALARA. The methods include the Radiological Work Permit (RWP), special equipment, technique, and practices as described in the following subsections. Work will be performed in accordance with reactor licenses and/or this Decommissioning Plan.

Radiological Work Permits (RWPs)

A Radiation Work Permit (RWP) will be used for the administrative control of personnel entering or working in areas that have radiological hazards present. Work techniques will be specified in such a manner that the exposure for all personnel, individually and collectively, are maintained ALARA. RWPs will not replace work procedures, but will act as a supplement to procedures. Radiation work practices will be considered when procedures are developed for work which will take place in a radiologically controlled area.

Project RWPs will describe the job to be performed, define protective clothing and equipment to be used, and personnel monitoring requirements. RWPs will also specify any special instructions or precautions pertinent to radiation hazards in the area including listing the radiological hazards present, area dose rates and the presence and intensity of hot spots, loose surface radioactivity, and other hazards as appropriate. The HP organization will ensure that radiation, surface radioactivity and airborne surveys are performed as required to define and document the radiological conditions for each job.

RWPs for jobs with low dose commitments will be approved at the HP technician or HP supervisory level while RWPs for jobs with potentially high dose commitment or significant radiological hazards will be approved by the RSO. Examples of topics covered by implementing procedures for the Radiation Work Permits are:

- Requirements, classifications and scope for RWPs;
- Initiating, preparing and using RWPs;
- Extending expiration dates of an RWP; and
- Terminating RWPs.

Respiratory Protection and TEDE ALARA Evaluations

The use of engineering controls to mitigate the airborne radiological hazard at the source will be the first choice with respect to controlling the concentrations of airborne radioactive material. There may be, however, circumstances where engineering controls are not practical, or may not be sufficient to prevent airborne concentrations in excess of those that constitute an airborne radioactivity area. In such circumstances where worker access is required, respiratory protective equipment will be utilized to limit internal exposures. Any situation wherein workers are allowed access to an airborne radioactivity area, or allowed to perform work that has a high degree of likelihood to generate airborne radioactivity in excess of 0.1 DAC, the decision to allow access will be accompanied by the performance of representative measurements of airborne radioactivity to assess worker intake. The results of DAC-hour tracking and air sample results for intake will be documented in accordance with appropriate regulations. Workers will provide nasal smears for HP evaluation following the use of respiratory protective equipment for radiological purposes, as necessary.

Control and Storage of Radioactive Materials

The UVA HP Program establishes radioactive material controls that ensure:

- Deterrence of inadvertent release of licensed radioactive materials to unrestricted areas.
- Confidence that personnel are not inadvertently exposed to licensed radioactive materials.
- Minimization of the volume of radioactive wastes generated during the decommissioning.

All material leaving the Restricted Area will be surveyed to ensure that radioactive material is not inadvertently released from the UVAR. See Section 3.1.3 "Radioactive Material Controls" for a description of the specific survey methods that will be used.

3.1.2 Health Physics Program

Project Health Physics Program - General

UVAR Health Physics has procedures in place which will be implemented during the UVAR Decommissioning Project. If additional Health Physics procedures are required at some point in the work to support the decommissioning, they will be developed and approved in accordance with UVA Health Physics policy and procedure.

UVA senior management is readily accessible to ensure timely resolution of difficulties that may be encountered. The RSO and Reactor H.P., while organizationally independent of the Project staff, have direct access to the Reactor Facility Director on a daily basis, and have full authority to act in all aspects of protection of workers and the public from the effects of radiation. Conduct of the UVAR Decommissioning Project HP program will be evaluated according to UVA policy.

Audits, Inspections, and Management Review

During Decommissioning Project work, aspects of the Project may be assessed and reported by the Contractor's Quality Assurance Department, through audits, assessments and inspections of various aspects of decommissioning performance, including HP, as described in Section 1.2.4.

Audits of the UVA Health Physics program are conducted in accordance with the requirements of 10 CFR 20. These audits will include aspects of the UVAR Decommissioning Project.

Additional assessments or management reviews may be performed when deemed appropriate by the Director of Environmental Health and Safety and/or the Reactor Facility Director.

Health Physics Equipment and Instrumentation

HP equipment and instrumentation suitable to permit ready detection and quantification of radiological hazards to workers and the public will be chosen to ensure the validity of measurements taken during remediation and final release surveys. The selection of equipment and instrumentation to be utilized will be based upon detailed knowledge of the radiological contaminants, concentrations, chemical forms and chemical behaviors that are expected to exist as demonstrated during radiological characterization, and as known from process knowledge of the working history of the UVAR. Equipment and instrumentation selection also takes into account the working conditions, contamination levels and source terms that are reasonably expected to be encountered during the performance of decommissioning work, as presented in this Plan.

The following sections present details of the equipment and instrumentation planned for use during the decommissioning. It is anticipated that through retirement of worn or damaged equipment/instrumentation or increase in quantities of available components or instruments, that new technology will permit upgrades or, at a minimum, like-for-like replacements. UVA is committed to maintaining conformance to minimum performance capabilities stated in this Plan whenever new components or instruments are selected.

Criteria for Selecting Equipment and Instrumentation for Conduct of Radiation and Contamination Surveys and Personnel Monitoring

A sufficient inventory and variety of instrumentation will be maintained on-site to facilitate effective measurement of radiological conditions and control of worker exposure consistent with ALARA, and to evaluate the suitability of materials for release to unrestricted use. Instrumentation and equipment will be capable of measuring the range of dose rates and radioactivity concentrations expected to be encountered during conduct of remediation and decontamination of the UVAR, as well as for final survey measurements, and to less than the minimum values required for release or ALARA decision-making.

Project HP staff will select instrumentation that is sensitive to the minimum detection limits for the particular task being performed, but also with sufficient range to ensure that the full spectrum of anticipated conditions for a task or survey can be met by the instrumentation in use. Consumable supplies will conform to manufacturer and/or regulatory recommendation to ensure that measurements meet desired sensitivity and are valid for the intended purpose. UVA will continue review of regulatory information notices and bulletins for applicability to Project HP instrumentation.

Storage, Calibration, Testing and Maintenance of Health Physics Equipment and Instrumentation

Survey instruments will be stored in a common location under the control of UVAR Decommissioning Project HP personnel. A program to identify and remove from service inoperable or out-of-calibration instruments or equipment as described in HP procedures will be adhered to throughout the UVAR Decommissioning Project. Survey instruments, counting equipment, air samplers, air monitors and personnel contamination monitors will be calibrated at license-required intervals, manufacturer-prescribed intervals (if shorter frequency) or prior to use against standards that are NIST traceable in accordance with approved calibration laboratory procedures, HP procedures, or vendor technical manuals. Survey instruments will be operationally checked daily when in use. Counting equipment operability will be verified daily when in use. The personnel contamination monitors are operationally tested on a daily basis when work is being performed.

Specific Health Physics Equipment and Instrumentation Use and Capabilities

Table 3-1 provides details of typical HP equipment and instrumentation that is planned for use in the UVAR Decommissioning Project. This list is neither inclusive or exclusive.

Table 3-1 Specific Health Physics Equipment and Instrumentation Use and Capabilities

Instrument Model	Detector Type	Instrument Range	Application
Eberline-RO-2 and 2A Eberline-RO-20	Ionization chamber	RO-2 0-5,000 mR/hr RO-2A 0-50 R/hr RO-20 0-60 R/hr	Beta/gamma exposure rate measurements
Eberline Teletector-6112/B	GM tube	0-1,000 R/hr	Telescoping detector for high range
Ludlum Model 2350/2350-1 Data Logger with 43-37 probe	Gas Flow Proportional	0-500,000 cpm	Alpha and beta/gamma floor monitor 550 cm^2 ^{137}Cs efficiency approximately 30% 4π ^{239}Pu efficiency appropriately 17% 4π
Ludlum Model 44-2 probe for use with 2350	1" x 1" NaI Scintillator	0-2,860 μR/hr (i.e., 0-2.8 mR/hr)	Gamma exposure rates
Ludlum Model 44-40 probe for use with 2350	GM tube	0-500,000 cpm	Shielded pancake detector ^{137}Cs efficiency approximately 19% 4π ^{239}Pu efficiency appropriately 15% 4π
Ludlum Model 43-68 probe for use with 2350	Gas Flow Proportional	0-500,000 cpm	Alpha and beta/gamma monitor 125 cm^2 ^{137}Cs efficiency approximately 30% 4π ^{239}Pu efficiency appropriately 20% 4π
Ludlum Model 43-94 pipe probe for use with 2350	Gas Flow Proportional	0-500,000 cpm	0.5 inch probe for 0.75 to 1 inch pipe diameters
Ludlum Model 43-98 pipe probe for use with 2350	Gas Flow Proportional	0-500,000 cpm	1.5 inch probe for 2 to 3 inch pipe diameters
Ludlum Model SP-113-3M pipe probe for use with 2350	3 GM tubes	0-500,000 cpm	Motorized spider probe with three 1.13" OD probes total area 19.4 cm^2 for 3 to 6 inch straight pipe
Ludlum Model SP-113-3T pipe probe for use with 2350	3 GM tubes	0-500,000 cpm	Motorized spider probe with three 1.13" OD probes total area 19.4 cm^2 for 3 to 6 inch pipe with bends
Ludlum Model SP-175-3 M pipe probe for use with 2350	3 GM tubes	0-500,000 cpm	Motorized spider probe with three 1.75" OD probes total area 46.5 cm^2 for 4 to 12 inch straight pipe
Tennelec Model LB 5100 W	Gas Flow Proportional	CPU operated	Low-Level α/β smear samples
Ludlum-177	ZnS(Ag) scintillation	0-500,000 cpm	Hand-held alpha frisker (50 cm^2 area) ^{239}Pu efficiency 15% 4π ^{230}Th efficiency 23% 4π
Ludlum Model 19 μR	NaI (Tl) Scintillator	0-5,000 μR/hr (i.e., 0mR/hr)	Low gamma exposure rates
Eberline Model RO-7	Ionization chamber	0-200 R/hr	Low to high gamma exposure rate measurements
EG&G NOMAD or equivalent Gamma Spectroscopy System	HPGe	N/A	Gamma spectrometry measurement of water, air, smear/media samples (e.g., soil, asphalt, concrete, tar, vegetation)
Eberline Personnel Contamination Monitor PCM-1B	Gas Flow Proportional	N/A	Personnel contamination monitor/walk-in monitor with microprocessor control

Instrument Model	Detector Type	Instrument Range	Application
F&J Model HV-1 "Hi-Vol"	N/A	5-30 cfm	High volume air sampling for minimum detection capability
F&J Model LV-14M Gooseneck "Lo-Vol"	N/A	0.35-3.5 cfm	Low volume air sampling for long term air sampling
Ludlum Model 333-2 air monitor	GM	$10\text{-}10^5$ cpm	Local airborne monitor with alarm capability

Policy, Method, Frequency and Procedures

The UVAR Decommissioning Project will utilize the existing UVA HP Program for the Project. This Program prescribes policy, method and frequency for effluent monitoring, conduct of radiological surveys, personnel monitoring, contamination control methods and protective clothing usage. This program may be augmented on a temporary basis to provide additional items related only to the UVAR decommissioning project.

Airborne Effluent Monitoring — During the decommissioning effort where a temporary barrier with an exhaust system is in use, the ventilation system exhaust points from the temporary barrier will be sampled continuously downstream of the HEPA filtration system.

Radiation Surveys — Radiation, airborne radioactivity and contamination surveys during decommissioning will be conducted in accordance with approved HP procedure(s). The purposes of these surveys will be to (1) protect the health and safety of workers, (2) protect the health and safety of the general public, and (3) demonstrate compliance with applicable license, federal and state requirements, as well as Decommissioning Plan commitments. HP personnel will verify the validity of posted radiological warning signs during the conduct of these surveys. Surveys will be conducted in accordance with procedures utilizing survey instrumentation and equipment suitable for the nature and range of hazards anticipated. Equipment and instrumentation will be calibrated and, where applicable, operationally tested prior to use in accordance with procedural requirements. Routine surveys are conducted at a specified frequency to ensure that contamination and radiation levels in unrestricted areas do not exceed license, federal, state or site limits. HP staff will also perform surveys during decommissioning whenever work activities create a potential to impact radiological conditions.

Personnel Monitoring - Internal and External — External monitoring will be conducted in accordance with approved procedures. Prospective external exposure evaluations will be performed, at a minimum, on an annual basis, or whenever changes in worker exposures warrant. Visitors to the UVAR will be monitored in accordance with requirements specified in UVA HP procedures and according to the radiological hazards of areas to be entered.

Internal monitoring will be conducted in accordance with approved procedures. This prospective internal exposure evaluation will be evaluated on an annual basis, at a minimum, or whenever significant changes in planned work evolutions warrant it. A comprehensive air sampling program will be conducted at the UVAR to evaluate worker exposures regardless of whether internal monitoring is specified. The results of this air sampling program will be utilized to ensure validity of specified internal monitoring requirements for decommissioning personnel. If, at any time during the decommissioning, hazards that may not be readily detected by the preceding measures are encountered, special measures or bioassay, as appropriate, will be instituted to ensure the adequate surveillance of worker internal exposure.

Monitoring will be required if the prospective dose evaluation shows that an individual(s) dose is likely to exceed 10% of the applicable limits, and for individuals entering a high or very high radiation area.

Respiratory Protection - The Decommissioning Project respiratory protection program will include direction for use of National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) certified equipment. This program will be reviewed and approved by UVA HP and UVA Industrial Hygiene to ensure adherence to the requirements of 10CFR20.

NIOSH/MSHA approved air purifying respirators include full face piece assemblies with air purifying elements to provide respiratory protection against hazardous vapors, gases, and/or particulate matter to individuals in airborne radioactive materials areas. Individuals may be required to use continuous or constant flow full-face airline respirators for work in areas with actual or potential airborne radioactivity. The RSO will also ensure that the respiratory protection program meets the requirements of 10 CFR Part 20, subpart H.

Maintenance — When respiratory protection equipment requires cleaning, the filter cartridges will be removed. The respirator will be cleaned and sanitized after every use with a cleaner/sanitizer and then rinsed thoroughly in plain warm water in accordance with HP procedures.

Storage — Respiratory protective equipment will be kept in proper working order. When any respirator shows evidence of excessive wear or has failed inspection, it will be repaired or replaced. Respiratory protective equipment that is not in use will be stored in a clean dry location.

Contamination Control - Contamination control measures that will be employed include, as appropriate, the following:

- Worker training will incorporate methods and techniques for the control of radioactive materials, and proper use and donning/doffing of protective clothing
- Procedures will incorporate HP controls to minimize spread of contamination during work
- Radiological surveys will be scheduled and conducted by HP

- Containment devices such as designed barriers, containers and plastic bags will be used to prevent the spread of radioactive material
- Physical decontamination of UVAR areas or items
- Physical barriers such as Herculite sheeting, strippable paint, and tacky mat step-off pads to limit contamination spread
- Posting, physical area boundaries and barricades
- Clean step-off pads at the entrance point to contaminated areas

Personnel entries into radiological contaminated areas will require the use of protective clothing. This clothing will consist of a suitable combination of items such as the following, dependent upon the conditions outlined in the RWP:

- Heavyweight lab coat
- Heavyweight canvas, cotton, or cotton/polyester coveralls
- Heavyweight hoods
- Plastic calf-high booties
- Rubber, plastic or cloth shoe covers
- Plastic or rubber gloves which may require cloth liners.
- Tyvek paper coveralls or plastic rain suit disposable outer clothing
- Face shield or other protective device

Access Control - A Restricted Area (RA) will be established and properly posted so as to prevent unauthorized access.

Engineered Controls - Personnel exposure to airborne radioactive materials will be minimized by utilizing engineering controls such as the following:

- Ventilation devices — in-place or portable HEPA filters or UVAR ventilation systems, local exhaust by use of vacuums
- Containment devices — designed containment barriers, containers, plastic bags, tents, and glove-bags
- Source term reduction — application of fixatives prior to handling, misting of surfaces to minimize dust and resuspension

Airborne Radioactivity Monitoring - Monitoring for the intake of radioactive material is required by 10 CFR 20.1502(b) if the intake is likely to exceed 0.1 ALI (annual limit on intake) during the year for an adult worker, or if the committed effective dose equivalent is likely to exceed 0.10 rem (1.0 mSv) for the occupationally exposed minor or declared pregnant woman. Air sampling will be performed in areas where airborne radioactivity is present or likely.

Prospective estimates of worker intakes and air concentrations used to establish monitoring requirements will be based on consideration of the following:

- The quantity of material(s) handled
- The ALI for the nuclides of interest
- The release fraction for the radioactive material(s) based upon its physical form and use
- The type of confinement being used for the material(s) being handled
- Other factors that may be applicable

HP personnel will use technical judgment in determining the situations that necessitate air sampling regardless of generalized, prospective evaluations done for the UVAR.

Prior to identifying the location for an air sampler, the purpose of the radiological air sample will be identified. Various reasons exist for collecting air samples. The following are a few examples:

- Estimation of worker intakes
- Verification of confinement of radioactive materials
- Early warning of abnormal airborne concentrations of radioactive materials
- Determining the existence of criteria for posting an Airborne Radioactivity Area (ARA).

Smoke tubes and buoyant markers may then be used to determine air flow patterns in the area. Air flow patterns may be reevaluated if there are changes at the UVAR that may impact the validity of the sampling locations. Such factors might include the following:

- Changes in the work process
- Changes in the ventilation system
- Use of portable ventilation that might alter earlier assessments

After identifying the purpose for the air sample and establishing flow patterns, air sample locations are chosen as follows:

- For verification of confinement of radioactive materials:

  – Locate samplers in the air flow near the potential or actual release point.
  – More than one sampling point may be appropriate when there are more than one potential or actual release points.

- For estimation of a worker intake:

  – Sampler intakes will be located as close to the workers breathing zones as practical without interfering with the work or worker

General workplace air sampler intakes will not be placed in or near ventilation exhaust ducts unless their purpose is to detect system leakage during normal operation, and if quantitative measurements of workplace concentrations are not required. Locations or number of air samplers will be changed when dictated by modifications to facility structure, changes in work processes, or elimination of potential sources.

A sufficient inventory and variety of operable and calibrated portable and semi-portable air sampling equipment will be maintained to allow for effective collection, evaluation, and control of airborne radioactive material and to provide backup capability for inoperable equipment. Air sampling equipment will be calibrated at prescribed intervals or prior to use against certified equipment having known valid relationships to nationally recognized standards. Table 3-1 lists anticipated air sampling equipment.

When the work being performed is a continuous process, a continuous sample with a weekly exchange frequency is appropriate. For situations where short-lived radionuclides are important considerations, the exchange frequency will be adjusted accordingly. Longer sample exchange frequencies may be approved by HP management for situations where airborne radioactive material and nuisance dust are expected to be relatively low. Grab sampling for continuous processes may also be approved by HP management based upon consideration of variability of the expected source term for the facility and process. Grab sampling is the appropriate means of airborne sampling for processes conducted intermittently, and for short duration radiological work that involves a potential for airborne release.

Potential Sources of Radiation or Contamination Exposure to Workers and Public as a Result of Decommissioning Activities

Sources of radiation or contamination exposure may be assessed by process knowledge, radiological survey data, surveys performed during characterization, previous and current job coverage surveys, or daily, weekly and monthly routine surveys.

Classification of potential sources may also be identified by radionuclide, physical properties, volatility and radioactivity.

Worker exposure to significant external deep-dose radiation fields is considered unlikely during this project due to the nature of the contaminants and/or the work precautions and techniques employed. Worker exposure to airborne radioactivity may occur during decontamination operations/work evolutions which may involve abrasives or methods that volatilize loose and/or fixed contamination.

Exposure of the public to external or internal radiation from this Decommissioning Project is not considered credible because of the confinement provided by the Facility and the access control provided for the Facility and the area surrounding it.

The types of exposure controls used take into account the current state of technology and the economics of improvements in relation to the benefits. Control of potential sources of radiation exposure to workers and public as a result of decommissioning activities will be achieved through, but not limited to, the use of administrative, engineering and physical controls.

Administrative controls consist of, but are not limited to:

- Administrative dose limits that are lower than regulatory limits
- Training
- Radiological surveys.

Physical barriers such as radiological warning rope/ribbon, in combination with radiological warning tape, lockable doors/gates as well as information signs and flashing lights or other applicable barriers may also be used.

Engineering controls may consist of but are not limited to:

- HEPA ventilation/enclosures
- Protective clothing/equipment
- Access restrictions/barriers
- Confinement.

Health Physics Policies for Contractor Personnel

Contractor personnel will be used during the UVAR Decommissioning Project. Contractors who will work with licensed radioactive materials will be required to:

- Attend and complete appropriate radiation safety course
- Provide required exposure history information
- Read and sign an applicable RWP and comply with instructions
- Follow all special instructions given by HP.

3.1.3 Radioactive Materials Controls

UVA's radiation protection program establishes radioactive material controls that ensure the following:

- Prevention of inadvertent radioactive material (licensed material) release to uncontrolled areas.

- Assurance that personnel are not inadvertently exposed to radiation from licensed radioactive materials.

- Minimization of the amount of radioactive waste material generated during decommissioning.

All materials leaving the UVAR Restricted Area will be radiologically surveyed to ensure that radioactive materials (i.e., licensed materials) are not removed inadvertently. Decommissioning Project and UVA Health Physics procedures will be used to ensure that potentially radioactive or contaminated items removed from the UVAR site are surveyed. The performance of these surveys will incorporate the guidance presented in *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for Licence Termination* (Ref. 3-1). The following survey methods will be used:

- **Materials and Equipment** - Direct frisking with a portable Geiger-Mueller detector (e.g., Ludlum Model 2300 with 43-68 probe, or equivalent) having a minimum level of detection of less than or equal to the lowest acceptable license termination screening values provided by the NRC in *Table 1 - Acceptable License Termination Screening Values of Common Radionuclides for Building Surface Contamination* (Ref. 3-2) or 7,100 dpm/l00 cm^2.

- **Smear Samples** - Analysis with a Gas Flow Proportional detector (e.g., Tennelec Model LB 5100 W or equivalent) having a minimum level of detection of less than or equal to 10% of the lowest acceptable license termination screening values provided by the NRC in *Table 1 - Acceptable License Termination Screening Values of Common Radionuclides for Building Surface Contamination* (Ref. 3-2) or 710 dpm/l00 cm^2.

- **Bulk Liquids or Bulk Materials** - Nuclide determinations of waste samples collected at the project site will be used to establish ratios between radionuclides that are gamma emitters and easily measured on-site and other nuclides which are either non-gamma emitters or require a more extensive analysis of quantity. Section 61.55(a)(8) of 10 CFR 61 permits licensees to determine the concentration of a radionuclide by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements.

  Liquids will be analyzed to insure that discharges to sanitary sewerage will meet the requirements of 10 CFR 20.2003 *Disposal by release into sanitary sewerage* and University of Virginia liquid discharge procedures.

Materials will be released if no discernable facility-related activity is detected within the capability of the survey methods presented above.

In evaluation of equipment and materials for fixed or smearable licensed radioactive materials, items painted with other than original manufacturer's paint will not be released unless clear process knowledge demonstrates that the paint was applied to a clean, non-radioactive surface prior to use in the UVAR Restricted Area or approval from Decommissioning Project Health Physics, has been obtained and an acceptable survey course for this situation has been approved. If the potential exists for contamination on inaccessible surfaces, the equipment will be assumed to be internally contaminated unless (1) the equipment is dismantled allowing access for surveys, (2) appropriate tool or pipe monitors with acceptable detection capabilities are utilized that would provide sufficient confidence that no licensed materials were present, or (3) it may readily be concluded that surveys from accessible areas are representative of the inaccessible surfaces (i.e., surveying the internal surface from both ends of a straight pipe from a nonradioactive process system with cotton swabs would be representative of the inaccessible areas).

If it is impractical or not possible to satisfy release criteria (or conclusively demonstrate that they have been met), the item will be dispositioned as radioactive waste.

3.1.4 Dose Estimates

The total projected occupational exposure to complete the Decommissioning of the UVAR is estimated to be 4 person-rem (estimated using Xtreme PM℠ (Ref. 3-3). A task-by-task breakdown of this dose estimate is provided herein as Table 3-2. Task-specific dose estimates are based on the nature of the work involved in each task item, the expected number of persons to be assigned to each task, and the individual task duration periods as shown on the overall project Schedule for UVAR D&D (see Figure 2-3).

This estimate is provided for planning purposes only. Detailed exposure estimates and exposure controls shall be developed in accordance with the requirements of the UVA ALARA program during detailed planning of the decommissioning activities. Area dose rates used for this estimate are based on process knowledge and current survey maps (where available). The Xtreme PM℠ system (Ref. 3-3) can be used to assist the project team in effectively managing the worker exposure and training and to document radiological conditions in work areas.

Table 3-2 UVAR Estimated Decommissioning Occupational Exposure

Task No.	Task Description	Subtotal pers-rem	Total Dose pers-rem
0.0	**Total Project**		**3.903**
1.0	**Prepare Plans and Procedures**		**0.000**
2.0	**Decontamination and Dismantling**		**3.875**
2.1	Undistributed Labor and Costs	0.137	
2.2	Mobilization and Training	0.001	
2.3	Site Verification Survey	0.018	
2.4	Remove Reactor Room Components	0.026	
2.5	Remove Reactor Components in Pool	1.234	
2.6	Reactor Pool Water	0.024	
2.7	Install Confinement Barrier Around Pool	0.006	
2.8	Reactor Hardware Removal	0.215	
2.9	Pool Remediation	1.247	
2.10	Ship Activated Material to Barnwell	0.000	
2.11	Dismantle Barrier and Package for Disposal	0.001	
2.12	Remove Control Rm and Equipment Rm	0.001	
2.13	Decontaminate Reactor Room	0.002	
2.14	Decommission Demineralizer Room	0.171	
2.15	Decommission Heat Exchanger Room	0.441	
2.16	Decommission BeamPort Facilities	0.162	
2.17	Decommission Hot Cells	0.035	
2.18	Decommission Labs and Structure	0.018	
2.19	General Outside Clean-Up	0.001	
2.20	Remove Fuel Transfer Tank	0.001	
2.21	Remove Cooling Tower	0.003	
2.22	Remove Buried Waste Tanks	0.088	
2.23	Remove Buried Hot Cell Tanks	0.033	
3.0	**Perform MARSSIM Site Release Survey**		**0.019**
4.0	**NRC Verification Survey**		**0.000**
5.0	**Facility Remediation**		**0.007**

The dose estimate to members of the public as a result of decommissioning activities is estimated to be negligible. This is because site perimeter controls will restrict members of the public from the area where decommissioning activities are taking place. This is consistent with the estimate given for the "reference research reactor" in the *"Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities"* (NUREG-0586) (Ref. 3-4). The dose to the public during decommissioning (DECON) and truck transport transportation of radioactive waste from the reference research reactor referred to in the Final Generic Impact Statement is estimated to be "negligible (less than 0.1 man-rem)."

Activated pieces and any contaminated debris will be removed and shielded if required to meet U.S. DOT shipping requirements and disposal site Waste Acceptance Criteria.

3.2 Radioactive Waste management

3.2.1 Radioactive Waste Processing

The processes of decontamination, remediation and dismantlement of the UVAR will result in solid and liquid low-level radioactive waste, mixed waste and hazardous waste. Limited soil remediation is anticipated which will result in solid radioactive waste. This waste will be handled (processed and packaged), stored and disposed of in accordance with applicable sections of the Code of Federal Regulations (CFR), disposal site Waste Acceptance Criteria, Virginia Administrative Codes, UVA Licenses and Permits, and the applicable implementing plans and procedures. Radioactive waste processing includes waste minimization or volume reduction, radioactive and hazardous waste segregation, waste characterization, neutralization, stabilization, solidification and packaging. The Xtreme PM℠ system (Ref. 3-3) can be used to assist the project team in effectively managing project waste, analytical results, waste stream characterization, waste related training, etc. The system's advanced estimating tools can be used to generate various waste handling scenarios to evaluate impacts from waste disposal options, waste processing options, transportation options, etc.

3.2.2 Radioactive Waste Disposal

Low-level radioactive waste will be processed and packaged for disposal at a licensed low-level waste site such as the Envirocare of Utah site or the Barnwell, South Carolina site. The volume of low-level radioactive waste is estimated at 12,500 Cu. ft. Mixed low-level waste will be prepared for shipment to off-site commercial processing and disposal facilities such as Envirocare of Utah.

10 CFR 61, *Licensing Requirements for Land Disposal of Radioactive Waste, Subpart D — Technical Requirements for Land Disposal Facilities*, establishes minimum radioactive waste classification, characterization and labeling requirements. These requirements will be ensured through the implementation of project packaging and characterization procedures, Disposal Site

Waste Acceptance Criteria and the Project-Specific Quality Assurance Plan. Training/ Qualifications will be provided for project waste management personnel to assure conformance to applicable 10 CFR 61 requirements as stated in the specific implementing procedures and plans. Audits and surveillances will be conducted per the Project-Specific Quality Assurance Plan based on ASME-NQA-1 and the requirements of 10 CFR 71.

10 CFR 71, Packaging and Transportation of Radioactive Material, establishes requirements for packaging, shipment preparation and transportation of licensed material. UVA is licensed by the USNRC to receive, possess, use and transfer licensed byproduct and source materials. 10 CFR 71 requirements will be met through the implementation of UVA approved packaging and shipping procedures. Training will be provided for waste management personnel to assure conformance to applicable 10 CFR 71 requirements. Quality Assurance will confirm conformance to 10 CFR 71 Subpart H (Quality Assurance) requirements through the implementation of an UVA approved Project-Specific Quality Assurance Plan.

10 CFR 20.2006, *Transfer for Disposal and Manifests*, establishes requirements for controlling transfers of low-level radioactive waste intended for disposal at a land disposal facility; establishes a manifest tracking system; supplements requirements concerning transfers and record keeping; and requires generator certification that transported materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transport. These requirements will be met through the implementation of project and UVA packaging and shipping procedures with the oversight of DOC and UVA Quality Assurance.

Radiological and mixed wastes will be disposed of at disposal sites per the applicable Disposal Site's Acceptance Criteria. Associated implementing plans and procedures will reflect the characterization, processing, removal of prohibited items, packaging and transportation requirements. Appropriate documentation will be submitted to designated disposal sites including, as required, certification plans, qualification statements, assessments, waste stream analysis, evaluations and profiles, transportation plans, and waste stream volume forecasts. Waste characterization, waste designation, waste traceability, waste segregation, waste packaging, waste minimization, and quality assurance and training requirements of the designated disposal sites will be incorporated in implementing procedures to assure conformance to disposal site requirements.

Generator State (Virginia) and Treatment/Storage/Disposal Facility States (Utah, South Carolina, etc.) requirements for radioactive and mixed waste management will be incorporated into plans and procedures to assure conformance with applicable state regulations, licenses and permits. Applicable state regulations include Virginia Hazardous Waste Management Regulations (Code of Virginia, Title 9), and Utah Department of Environmental Quality Rules (R313) for the control of ionizing radiation reflected in Envirocare's Utah Radioactive Material License, UT 2300249.

Radioactive waste will be staged in designated controlled areas in accordance with USNRC 10 CFR 19 and 20 requirements. Mixed wastes will be staged in designated controlled areas per EPA 40 CFR requirements, 10 CFR 19 and 20, and per local and state permits. Measures will be implemented through plans and procedures to control the spread of contamination, limit radiation levels, prevent unauthorized access, prevent unauthorized material removal, prevent tampering, and prevent weather damage. The designated controlled areas will be approved by Radiological Work Permits, and/or Hazardous Work Permits.

Radioactive and mixed waste material will be packaged for shipment per 10 CFR, 40 CFR, 49 CFR, and the designated Disposal Site Criteria and placed in permitted interim storage (staged) until shipped. The quantity of waste packages staged for shipment will be a function of waste generation and packaging rate, shipment preparation rate, shipment rate, and disposal site acceptance rate. To meet this objective, shipments will be scheduled throughout the life of the Project to designated treatment, storage, and disposal facilities.

Radioactive material storage areas will be contained inside posted restricted areas according to existing UVA procedures and consistent with 10 CFR 20.

3.3 General Industrial Safety Program

Industrial Safety and Industrial Hygiene personnel, with Project Management, shall be responsible to ensure that the Project meets occupational health and safety requirements of Project personnel and the general public. The primary functional responsibility is to ensure compliance with the OSHA of 1973. Specific responsibilities include conducting an industrial training program to instruct employees in general safe work practices; reviewing Decommissioning Project procedures to verify adequate coverage of industrial safety and industrial hygiene concerns and requirements; performing periodic inspections of work areas and activities to identify and correct any unsafe conditions and work practices; providing industrial hygiene services as required; and advising Project management on industrial safety matters and on the results of periodic safety inspections.

All personnel working on the UVAR Decommissioning Project will receive Health and Safety training in order to recognize and understand the potential risks involving personnel health and safety associated with the work at the UVAR. The Health and Safety training implemented at the UVAR is to ensure compliance with the requirements of the USNRC (10 CFR), the EPA (40 CFR), and OSHA (29 CFR). Workers and regular visitors will be familiarized with plans, procedures and operation of equipment to conduct themselves safely. In addition, each worker must be familiar with procedures that provide for good quality control. Section 2.5, Training Program, provides additional information. The Xtreme PM℠ system (Ref. 3-3) can be used to assist the project team in effectively managing training requirements, training status, safety equipment, etc.

3.4 Radiological Accident Analyses

Ppotential radiological accidents during the decommissioning of the UVAR will be mainly associated with the reactor pool. Factors considered in assessing potential radiological accidents are:

1) Pool hardware storage and removal
2) Fire
3) Other considerations.

Pool Hardware Storage and Removal

Radiological accidents could occur during removal and packaging of activated components and equipment. However, this risk is very low considering the administrative precautions which will be taken during decommissioning. UVAR and contractor experience in handling of activated/contaminated components, and control of job activities utilizing written and approved procedures, will ensure the safe conduct of the project.

The water-filled pool provides shielding for workers positioned near or over the reactor during hardware handling. Any failure to meet shielding requirements would result in worker restrictions on approach to the pool until the requirement could be met.

Fire

Portable extinguishers will be provided as needed. External fire department support is provided for by the UVAR Emergency Plan. The radiological hazard resulting from a fire would be minimal.

Other Considerations

Consequences of a pool leak are low because the poolwater is continuously filtered and deionized and contains negligible radioactivity. The potential leak could result in flowing water carrying loose contamination to a new location within the facility, outside the facility, or into the soil. Since loose contamination is minimal the risk of spread of contamination is low. There is no potential for airborne contamination from such an event.

REFERENCES FOR SECTION 3

3-1 *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for Licence Termination,* the Federal Register (63 FR 64132, 11/18/98)

3-2 *Table 1 - Acceptable License Termination Screening Values of Common Radionuclides for Building Surface Contamination*

3-3 Xtreme PM℠, Integrated Project Management System, GTS Duratek and Merrimac.

3-4 NUREG-0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*

4.0 PROPOSED FINAL RADIATION SURVEY PLAN

The intended course of action for UVAR decommissioning, based upon consideration of site and facility radiological characterization results, is to decontaminate structural materials to the extent practicable in balance with radioactive waste minimization considerations, and dismantle UVAR systems to the extent necessary for remediation, and packaging for burial those materials that cannot reasonably be decontaminated. As such, the Final Release Survey Plan (and subsequent Final Survey Report) discussed in this section deals with release of the UVAR building structure and grounds to unrestricted use. This section will also discuss the survey methods that will be utilized.

4.1 Description of Final Radiation Survey Plan

The purpose of the Final Radiation Survey is to demonstrate that the radiological condition of the UVAR site structures are at or below established release criteria (see Section 2.7) in anticipation of U.S. NRC approval to terminate the UVAR Reactor licenses and to release the facility housing the UVAR for unrestricted use. The Final Release Survey Plan (and report) will deal with release of the UVAR structure and site to unrestricted use.

UVA will develop its Final Release Survey Plan using the guidance provided in DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination* (Ref. 4-1) and NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 4-2).

4.1.1 Means for Ensuring that all Equipment, Systems, Structures and Site are Included in the Survey Plan

Every item that is to be removed from the UVAR will be evaluated for its ability to be decontaminated. Further, items will be radiologically surveyed to ensure that radioactive (i.e., licensed) materials are not inadvertently removed from the facility (see Section 3.1.3). When it is impractical or not possible to decontaminate an item such that it exhibits no discernable facility-related activity when surveyed following methods presented in Section 3.1.3, the item will be treated as radioactive waste. The systematic approach to UVAR decommissioning will ensure that every item or structural component in the UVAR is specifically evaluated for release before beginning the Final Release Survey. The Final Release Survey will break the UVAR into three classes (as suggested in MARSSIM) to ensure adequate survey coverage in support of a license termination request and subsequent release of the property for unrestricted use.

4.1.2 Means for Ensuring that Sufficient Data is Included to Achieve Statistical Goals

UVA will develop the UVAR Final Release Survey Plan using the guidance presented in DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination* (Ref. 4-1) and NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 4-2). By using this guidance, the Project will satisfy the U.S. NRC recommended statistical goals.

4.2 Background Survey Results

The Final Release Survey Guideline values for residual activity are taken to be levels above the naturally occurring background radiation. However, if the final release survey values are significantly below the release guideline levels, the licensee may opt not to use background subtraction. The number of samples collected in each survey unit and in background reference areas will be sufficient to satisfy the statistical goals. The final release measurements will consist of a combination of direct beta/gamma measurements, samples for removable alpha and beta contamination and samples for radionuclide specific analysis.

Background radiation as encountered at any location includes contributions due to soil natural radiation sources and man-made sources. Natural radiation sources include terrestrial radioactivity due to naturally-occurring radioisotopes in soils and construction media, airborne radioactivity (principally radon and radon progeny) from the radioactive decay of certain of these naturally occurring radioisotopes, and cosmic radiation from high-speed particle interactions in the earth's atmosphere. Man-made background radiation, as it would impact the Final Release Survey, would consist primarily of atmospheric of fission product fall-out due to weapons testing and reactor accidents and any contribution that might exist as a result of activities of other licensees.

The general area background radiation, as would be measured with a micro-R meter, is influenced by a number of factors, principally the naturally-occurring radioactivity in soils and other nearby materials, radon and radon progeny concentrations in the air, and extent of cosmic radiation (which varies with elevation). Due to the number of influences, the natural background varies appreciably from location to location, day-to-day (even time of day) and season-to-season as related to changing weather conditions and materials in the surroundings.

The *Characterization Survey Report for the University of Virginia Reactor Facility* (Ref. 4-3) includes measurements to establish background radioactivity in soils, concrete and asphalt considered representative of those that would be encountered in the Final Release Survey. One of the principal constituents of global fallout, ^{137}Cs, found as a result of atmospheric weapons testing, is also the principal fission product contaminant at the UVAR. ^{137}Cs has been seen to be persistent in the upper 15 cm (6 in.) of soil with concentrations decreasing beyond this depth.

Release guideline values were established as an increment in excess of background values. Therefore, the Final Release Survey will include the establishment of background area radiation levels using the guidance in MARSSIM and RG-4006. Asphalt, concrete and other construction material background values have been established by taking measurements on unaffected UVA construction materials.

4.3 Final Release Criteria - Residual Radiation and Contamination Levels

The criteria for release of the UVAR facility/site to unrestricted use, after completion of the decommissioning activities described in this plan, are presented in Section 2.7. In summary, they are: 1) those given in the *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for Licence Termination,* the Federal Register (63 FR 64132, 11/18/98) (Ref. 4-4), and 2) a 25 mR/yr unrestricted release dose limit in 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use* (Ref. 4-5).

4.4 Measurements for Demonstrating Compliance with Release Criteria

4.4.1 Instrumentation - Type, Specifications and Operating Conditions

Instrumentation utilized during the Final Release Survey (and equipment and materials survey) will be selected based upon the need to ensure that site residual radiation will not exceed the release criteria. In order to achieve this goal, instrumentation sensitive to the isotopes of concern and capable of measuring levels below 50% of the guideline values for those isotopes will be selected. Instrumentation available for the Final Release Survey, and their respective detection range capability is presented in Table 3-1 of this plan. Instrumentation sensitivities were determined following the guidance of NUREG-1507 (Ref. 4-6) using nominal literature values for background, response and site conditions. Refinements to these detection sensitivity estimates will be made, as necessary, on the basis of actual instrument response and background data gathered during site survey activities. Instrumentation used in the surveys will be calibrated against sources and standards that are NIST-traceable and representative of the isotopes encountered at the UVAR. When to be used, instruments will be operationally tested daily, or prior to each use, whichever is less frequent. Instruments will not be used in conditions that are not in conformance with manufacturer recommendations.

4.4.2 Measurement Methodology for Conduct of Surveys

This Decommissioning Plan presumes that the UVAR will have been decontaminated to the extent practicable prior to the Final Release Survey. The UVAR structure and site will be methodically remediated, as necessary, prior to conduct of the Final Release Survey. The characterization results and the continuous feedback from remediation surveys will be the basis for remediation efforts. The UVAR Final Release Survey Plan will include several steps to calculate the number of measurements and samples required, according to MARSSIM guidance, to release the site without restrictions. These steps include:

- Classify survey units

- Specify the decision error
- Determine the DCGL
- Calculate the relative shift
- Obtain the number of samples per survey unit
- Estimate the sample grid spacing
- Perform evaluation for small areas with elevated radioactivity
- Determine if the number of samples is reasonable.

<u>Classify Survey Units</u>

The UVAR site will be broken into four classes of survey areas. Class 1 is an area with the highest potential for contamination. Class 2 is an area that was impacted or has a low potential for delivering a dose above the release criteria and has little or no potential for containing small areas of elevated activity. Class 3 is an area with the lowest potential for contamination. Class 4 is a non-impacted area where there is no potential for contamination. The characterization survey document (Ref. 4-3) indicates the survey classification for the various parts of the UVAR facility.

<u>Specify the Decision Error</u>

There are two types of decision error (applied here to analytical results): Type I (alpha) and Type II (beta). A Type I error is described as the probability of determining that a result is above a criterion when it actually is not (false positive). A Type II error is described as the probability of determining that a result is below a criterion when it actually is above it (false negative). Both types of error are typically set at 0.05 (5%) at first, but the final values may differ depending on the data quality objectives.

<u>Determine the DCGL</u>

The derived concentration guideline level (DCGL) is defined in MARSSIM as the radionuclide-specific concentration within a survey unit corresponding to the release criterion. The radionuclides identified in the UVAR and adjacent yards during radiological characterization efforts were ^{137}Cs (predominant nuclide), ^{60}Co, ^{54}Mn, ^{55}Fe, ^{57}Co, ^{63}Ni, ^{65}Zn, ^{125}Sb, ^{154}Eu, $^{233/234}$U and ^{241}Pu. The DCGL values were discussed in Section 2.7.

<u>Calculate the Relative Shift</u>

The relative shift is defined as the Δ/σ, where Δ is the DCGL = LBGR (lower bound of the gray region) and σ is the standard deviation of the contaminant distribution. MARSSIM suggests that the LBGR initially be set at one-half of the $DCGL_W$, but it can be adjusted later to provide a Δ/σ value in the recommended range of 1 to 3. The weighted DCGL, or $DCGL_W$, is the concentration *averaged over a survey unit* that can be present while still satisfying the criterion (averaging accounts for the commonly inhomogeneous nature of contamination). Site specific data will be used to estimate σ.

Obtain the Number of Samples per Survey Unit

The calculated value for Δ/σ can be used to obtain the minimum number of samples necessary to satisfy requirements. Table 5.3 in MARSSIM contains the number of samples necessary for a given Type I error (α) or Type II error (β) and Δ/σ if the radionuclide(s) is present in background. Table 5.5 in MARSSIM contains the number of samples in each survey unit when the radionuclide(s) is not present in background.

Estimate the Sample Grid Spacing

The grid spacing, L, will be determined based upon A, the surface area in the survey unit, and n, the number of samples. The grid spacing for a triangular grid is estimated as follows:

$$L = \sqrt{\frac{A}{0.866\ x\ n}}$$

Perform Evaluation for Small Areas with Elevated Radioactivity

After the grid spacing has been calculated, the area between samples can also be calculated. For example, if the grid spacing is 10 m for a square grid, then there can be an undetected pocket of elevated radionuclide concentrations 100 m^2 in area. Adjustments to the grid spacing (i.e., additional sampling) may be necessary depending on the following three factors:

- The class of the survey unit;
- The ability to scan for the radionuclide; and
- The minimum potential size of the elevated activity that could produce an exposure above the dose or risk criterion.

Determine if the Number of Samples is Reasonable

Assuming that the number of samples per unit has been calculated, it should then be determined if that number is reasonable. It is possible, even if MARSSIM guidance was strictly followed, that there are too few samples to produce the desired level of comfort. It is the responsibility of the site managers and health physicists to evaluate whether the number of samples is reasonable.

If it is determined that the number of samples is inadequate or excessive, the data quality objectives should be reevaluated.

4.4.3 Scan Surveys

Following remediation and prior to conducting sampling, screening beta/gamma scans for surfaces and structures and gamma scans for environs will be performed over 100% of surfaces of both Class 1 and Class 2 survey units and 25% of the Class 3 survey unit. A scanning response exceeding an action level set based on Section 6.8.2 of NUREG-1507 will be investigated/sampled/re-surveyed and, if necessary, remediated. If remediation is performed, scanning shall be repeated to demonstrate effectiveness of the remediation.

4.4.4 Soil Sampling

Soil samples will be obtained to a depth of 15 cm; samples will be packaged and uniquely identified in accordance with chain-of-custody and site-specific procedures.

4.4.5 Sample Analysis

Samples will be transferred to a radio-analytical laboratory for analyses in accordance with documented laboratory-specific standard methods. In accordance with MARSSIM, analytical techniques will provide a minimum detection level of 50% of the individual radionuclide $DCGL_W$ (or $DCGL_{EMC}$) values for all primary contaminants. If these analyses indicate residual activity exceeding guideline levels, further remediation will be performed, as required, and scans and sampling of the remediated area will be repeated.

4.4.6 Investigation Levels

Radiation levels identified by scans that indicate potential residual radioactive contamination above background will be investigated to identify the source, level and extent of such residual activity. Areas which contain residual radioactivity concentrations of individual radionuclides, or sum-of-ratio concentrations above respective guideline values, will be remediated, reclassified (as necessary) and re-surveyed.

4.5 Methods to be Employed for Reviewing, Analyzing, and Auditing Data

4.5.1 Laboratory/Radiological Measurements Quality Assurance

During decommissioning survey activities, many direct and indirect measurements and sample media samples will be collected, measured and analyzed for radiological contaminants. The results of these surveys will be utilized to evaluate the suitability of the material or item for release to unrestricted use, or whether decontamination of structures, components, and the surrounding site have achieved the desired result. Sample collection, analysis, and the associated documentation will adhere to written procedures and meet the guidance of the U.S. NRC, as well as comply with recognized industry recommendations and good practices. Outside (i.e., non-UVA) laboratories selected to analyze UVAR decommissioning samples shall be approved by UVA and listed on the QA Approved Suppliers List.

Organizations that perform radiological monitoring measurements recognize the need to establish quality assurance programs to assure that radiological monitoring measurements are valid. These programs are established for the following reasons: (1) to readily identify deficiencies in the sampling and measurement processes to those individuals responsible for these activities so that prompt corrective action can be taken, and (2) to routinely monitor the survey and laboratory measurement results in order to assure that results and conclusions are valid.

4.5.2 Supervisory and Management Review of Results

Radiological surveys will be conducted by Health Physics technicians who are trained and qualified. In addition, radiological surveys and sample results will be reviewed by a senior level member of the Health Physics staff other than the individual that performed the survey. Final Radiation Survey data will also be reviewed by the RSO.

REFERENCES FOR SECTION 4

4-1 DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination*

4-2 NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*

4-3 *Characterization Survey Report for the University of Virginia Reactor Facility*, December 1999.

4-4 *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for Licence Termination,* the Federal Register (63 FR 64132, 11/18/98)

4-5 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use*

4-6 NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*

5.0 TECHNICAL SPECIFICATIONS

It is anticipated that for decommissioning the applicable Technical Specifications for the UVA Reactor will be set forth in Amendment No. 25 to Facility License No. R-66, University of Virginia Reactor, Docket No. 50-62, issued by the USNRC in early year 2000, as per UVA request dated August 16, 1999 (Ref. 5-1).

As decommissioning progresses, further requests for changes to the Technical Specifications may be submitted in an application for amendment to the license pursuant to 10 CFR 50.59.

REFERENCES FOR SECTION 5

5-1 Amendment No. 25 to Facility License No. R-66 (UVA Reactor) — University of Virginia, Anticipated Issue in early year 2000 by the USNRC, as per UVA request dated August 16, 1999.

6.0 PHYSICAL SECURITY PLAN

All UVA radiation restricted areas are secured from unauthorized entry. During non-working hours, all nuclear facility sensitive areas are locked. UVA maintains routine, periodic police surveillance of the reactor site.

Existing physical security and material control and accounting plans approved by the Nuclear Regulatory Commission, as may be amended, will continue to be implemented.

These existing plans meet the requirements in NUREG-1537 Chapter 17 *Decommissioning and Possession-Only Amendments,* and will be maintained as required by the UVAR Possession Only Amendment (Ref. 6-1).

REFERENCES FOR SECTION 6

6-1 Amendment No. 25 to Facility License No. R-66 (UVA Reactor) — University of Virginia, Anticipated Issue in early year 2000 by the USNRC, as per UVA request dated August 16, 1999.

7.0 EMERGENCY PLAN

As required by the USNRC, The University of Virginia has a Reactor Facility Emergency Plan for responding to emergencies at the Reactor Facility. The purpose of this plan is to minimize any emergency's effect on the public, personnel, reactor facility and the environment surrounding the facility. Removal of spent fuel from the site, and storage of on-site Co-60 pins in an approved cask, have significantly reduced the potential for significant release of radioactive material offsite. Any airborne or liquid releases due to decommissioning activities would have negligible impact offsite. The most likely accident scenario is a contaminated and/or injured individual. This scenario is adequately addressed by the existing emergency plan. Training will be provided to key personnel to ensure their familiarity with the emergency plan and their expected responses.

8.0 ENVIRONMENTAL REPORT

The Environmental Report (Ref. 8-1) is provided as Appendix B.

REFERENCES FOR SECTION 8

8-1 *Environmental Report for the University of Virginia Reactor Decommissioning*, February 2000.

9.0 CHANGES TO THE DECOMMISSIONING PLAN

As the decommissioning progresses, and up until the termination of the license, changes to the Technical Specifications will be via a Request for License Amendment pursuant to 10 CFR 50.90 (Ref. 9-1).

UVA requests that changes to the Decommissioning Plan be allowed with local approval by the Reactor Director or the Reactor Decommissioning Committee, and without prior USNRC approval, unless an unreviewed safety question is involved. An unreviewed safety question involves:

1. The increase of probability of occurrence or the increase of consequences of an accident or malfunction of equipment important to safety compared to that situation previously evaluated in the SAR, or

2. The possibility for an accident or malfunction of a different type than previously analyzed in the SAR, or

3. The reduction in margin of safety as defined in the SAR.

Reports and records of changes to the Decommissioning Plan, and retention of documents, will be in accordance with the applicable portions of 10 CFR 50.59 (Ref. 9-2).

REFERENCES FOR SECTION 9

9-1 10 CFR 50.90, *Application for amendment of license or construction permit.*
9-2 10 CFR 50.59, *Changes, tests and experiments*.

APPENDIX A

SUMMARY OF CHARACTERIZATION RESULTS

SUMMARY OF CHARACTERIZATION RESULTS

The University of Virginia Reactor (UVAR) was permanently shut down in June of 1998 following the decision to cease operations and to decontaminate and decommission (D&D) the facility. GTS Duratek (GTSD) was awarded a contract to assist the University of Virginia (UVA) in its efforts to characterize the UVAR facility and site. GTSD assisted UVA by performing a characterization survey of the UVAR, as well as the surrounding buildings and environs.

The characterization followed guidance provided in NUREG-1575, MARSSIM, and it entailed performing a site investigation, preparing plans, performing a comprehensive radiation survey and sampling for potential hazardous materials at the site. The site investigation involved a site walk-down, historical site assessment, operational history investigation, and determination of the facility source term. The Characterization Survey Plan, the Quality Assurance Plan, the Site Health and Safety Plan and the Project Management Plan were developed using the information obtained from the site investigation. The plans were developed by GTSD staff from the Radiological Engineering and Field Services office in Kingston, Tennessee and reviewed and approved by UVA for use at the project site. Data quality objectives (DQO's) were included in the plans. Characterization of the UVAR facility and site was performed according to these plans, and the characterization survey met the DQO objectives.

Included in the planning was the development of derived concentration guideline levels (DCGL's) for radionuclides assumed to be present at the site. The characterization DCGL's were developed to meet the intent of Subpart E, 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use*. The DCGL's were used to select instruments and to develop parameters for instrument operation so that the level of sensitivity for radiation measurements taken during the survey would be less than 50% of the characterization DCGL's.

Once the planning phase was completed, the survey team mobilized to the site and a kick-off meeting was held between GTSD and UVA personnel. Survey equipment was set up and all required training was completed. Over the course of eight and one-half weeks, eighteen survey packages describing rooms and areas of the UVAR facility and site surfaces, structures and environs were completed. Each survey package contained detailed instructions, drawings and location codes to perform or collect the 2,655 measurements and/or samples for the characterization.

The measurements and samples collected for the radiological characterization included direct alpha measurements, direct beta measurements, smear samples for removable alpha and beta contamination, smear samples for removable tritium contamination, exposure rate measurements and soil, sediment and water samples for gamma spectrum analysis. During the hazardous material assessment, survey package instructions were developed and measurements were performed and/or collected for lead and asbestos at the facility. In addition, samples were collected and sent offsite for analysis of potential hazardous material constituents. The purpose of the hazardous material assessment was to recognize hazardous materials that may be present for the D&D phase of the work, and to meet the Waste Acceptance Criteria for waste shipments to Envirocare of Utah.

Survey package instructions were developed and measurements performed for background surface, structure and environs reference areas. Direct beta background values were determined for naturally occurring radioactive materials (NORM) in asphalt, brick, ceramic tile, cinder block and concrete. These background values were applied to the direct beta measurements collected at the UVAR facility surfaces and structures to determine the net beta activity results per 100 cm^2 from the measured activity results. Also, survey measurements and samples collected from sediment and water of the environs were used to determine background values for NORM and from weapons testing. These values are included in the characterization report (Ref. A-1) but were not applied to UVAR survey results.

One resin sample from the UVAR poolwater clean-up system and one pond sediment sample (taken where the facility drains enter the pond) were collected and sent offsite for 10 CFR Part 61 radionuclide analysis. These sample results and the other onsite characterization results were used to develop UVAR site-specific DCGL's for site clean-up and release for unrestricted use.

The UVAR facility and site, for the most part, are below the radiological characterization DCGL and are mostly free from hazardous material concerns. However, some areas and locations at the UVAR facility and site will require decontamination before the site is suitable for NRC license termination. Of the 2,655 total samples and measurements collected and performed for the survey, 1,142 of them were direct measurements collected for the radiological characterization. Twelve (12) direct beta measurement results were greater than the MDA goal (50 % of the 5,000 dpm/100 cm^2 characterization DCGL) and five (5) of these direct beta measurements were greater than the characterization DCGL (9,250 dpm/100 cm^2). Of the 198 samples collected for gamma spectrum analysis, 18 sample results were greater than the characterization soil concentration DCGL's (1.91 pCi/g for Co-60 and/or 0.95 pCi/g for Cs-137). Details of these surveys and complete results are provided in the UVAR Characterization Survey Report (Ref. A-1).

The areas that will require remediation or further investigation and evaluation are presented in the discussions that follow. The location of the elevated measurements are depicted in Figures A-1 to A-4 by number on each figure.

1. Figure A-1, *Reactor Facility First Floor Level*, Location No. 1, one confinement room elevated measurement result of 12,593 dpm/100 cm^2 was obtained on the East wall. However, this result may have been influenced by elevated background radiation levels due to radioactive materials stored in the area. The radioactive materials stored in the reactor confinement room during this survey period will be removed prior to, or as a part of, the facility decommissioning. Measurement results from the three floor drains in the

confinement room showed contamination levels up to 6,398 dpm/100 cm² in floor drain number 2 on the east side of the reactor pool.

2. Figure A-1, *Reactor Facility First Floor Level*, Location No. 2, the reactor pool will require remediation based upon the operational history, radioactive materials known to be present in the pool and activation products from reactor operations in the concrete walls and floor.

3. Figure A-1, *Reactor Facility First Floor Level*, Location No. 3, a composite sediment sample, collected from the exhaust of the confinement building stack during the building exterior surfaces survey, measured 0.8 pCi/g of Co-60 and 2.8 pCi/g of Cs-137.

4. Figure A-2, *Reactor Facility Mezzanine Level*, Location No. 4, in room M008 one elevated direct measurement result of 26,365 dpm/100 cm² total beta activity was obtained from the laboratory sink. The contaminant was suspected to be Nickel-63 based on research experiment history and the low-energy of the measured activity.

5. Figure A-2, *Reactor Facility Mezzanine Level*, Location No. 5, in room M021A one elevated direct measurement result of 8,318 dpm/100 cm² total beta activity was obtained from the equipment surface of the reactor pool water clean-up system. However, this surface contamination measurement result may have been influenced by elevated background radiation levels from the water clean-up system internal contamination. The water clean-up system tanks, pumps and piping and the prototype water clean-up system tank and piping located in the adjacent room M021 will be removed as a part of the facility decommissioning.

6. Figure A-3, *Reactor Facility Ground Level*, Location No. 6, the measurement results from the survey indicate that room G007 excluding any CAVALIER Reactor, supporting systems, the sub-critical reactor assembly and pit for the most part was radiologically clean. Measurements performed on the sub-critical reactor assembly and pit were inconclusive due to elevated natural radon activity. An NRC approved decommissioning plan and decommissioning order is in place for the CAVALIER Reactor, supporting systems. The sub-critical reactor assembly located in room G007 is scheduled for shipment back to Oak Ridge (DOE). The CAVALIER Reactor, and supporting systems and the sub-critical reactor assembly will be decommissioned in accordance with the approved plan.

7. Figure A-3, *Reactor Facility Ground Level*, Location No. 7, the Hot Cell rooms G026 and G027 each had one elevated direct measurement result greater than 9,250 dpm/100 cm² total beta activity. Results of measurements collected ranged up to 63,661 dpm/100 cm² on the floor in room G026 and up to19,268 dpm/100 cm² on the floor in room G027. Results from a concrete core bore slice indicated Cs-137 contamination of 7,650 pCi/g in the first 1/4" depth at the elevated reading location in room G026.

8. Figure A-3, *Reactor Facility Ground Level*, Location No. 8, the sump in the heat exchanger room G024 had a gamma spectrum analysis result indicating radionuclide activity above the characterization DCGL's for Co-60 and Cs-137. The sump in this room will require decontamination and the heat exchanger system, pumps and piping in the room G024 will be removed during decommissioning.

9. Figure A-3, *Reactor Facility Ground Level*, Location No. 9, in room G028 one elevated direct measurement result of 8,246 dpm/100 cm² total beta activity was obtained from the east wall mid-way between rooms G024 and G025 and one elevated direct measurement result of 7,522 dpm/100 cm² total beta activity was obtained from the north wall outside of room G022. However, these surface contamination measurement results may have been influenced by elevated background radiation levels from radioactive materials stored in the area during the time of the survey. Rooms G007, G007A, G018, G019, G022 and G028 were used for, and posted as, radioactive material storage areas. The radioactive materials stored in the rooms during this characterization survey will be removed as a part of the facility decommissioning.

10. Figure A-3, *Reactor Facility Ground Level*, Location No. 10, one elevated direct measurement result of 5,758 dpm/100 cm² total beta activity was obtained from the beam tube pipe end in the southeast port movable shield plug on the side oriented toward the reactor. However, this measurement result may have been influenced by elevated background radiation levels from radioactive materials stored in room G022 during this survey. A gamma scan survey profiling of the North and South Fast Neutron Beam Ports in conjunction with knowledge of the operational history indicates that the beam ports will need to be removed as a part of the facility decommissioning.

11. Figure A-4, *Reactor Facility Grounds*, Location No. 11, the Buried Liquid Waste Holding Tank Bunker dirt floor and tank interiors had gamma spectrum analysis results above the characterization DCGL's for Co-60 and Cs-137. The radionuclides contamination was present in the dirt floor to a 30" depth. Two elevated direct measurement results were obtained, 5,541 dpm/100 cm² total beta activity from the east tank and 6,600 dpm/100 cm² total beta activity from the west tank.

12. Figure A-4, *Reactor Facility Grounds*, Location No. 12, the Hot Cell Buried Waste Holding Tanks had elevated direct measurements ranging up to 16,907 dpm/100 cm² total beta activity in the piping leading to the tanks. A sample of sediment collected from inside the pipe indicated the presence of Cs-137. Five (5) water and sediment samples were collected from the tank contents for gamma spectral analysis and one result indicated the presence of Cs-137 activity above the characterization DCGL.

13. Figure A-4, *Reactor Facility Grounds*, Location No. 13, a pond sediment sample collected and sent offsite for 10 CFR Part 61 analysis indicated the presence of Co-60 and

Cs-137 activity above the characterization DCGL. The sample was a composite of surface sediment collected around the vertical end of the reactor facility drain pipe at the pond.

14. Figure A-4, *Reactor Facility Grounds*, Location No. 14, soil samples in the outfall area between the buried liquid waste holding tank bunker and the pond indicated activity above the characterization DCGL's for Co-60 and Cs-137. Samples were taken at 0-6" and 6-12" depths approximately half-way down the bank at the location of the drain pipe from the bunker.

15. Figure A-4, *Reactor Facility Grounds*, Location No 15., one sediment sample collected for gamma spectrum analysis from the storm drain in the parking lot area on the south side of the facility indicated activity above characterization DCGL's for Co-60 and Cs-137.

REFERENCES FOR APPENDIX A

3-1 UVAR Characterization Survey Report

Figure A-1 UVA Reactor Facility First Floor Level

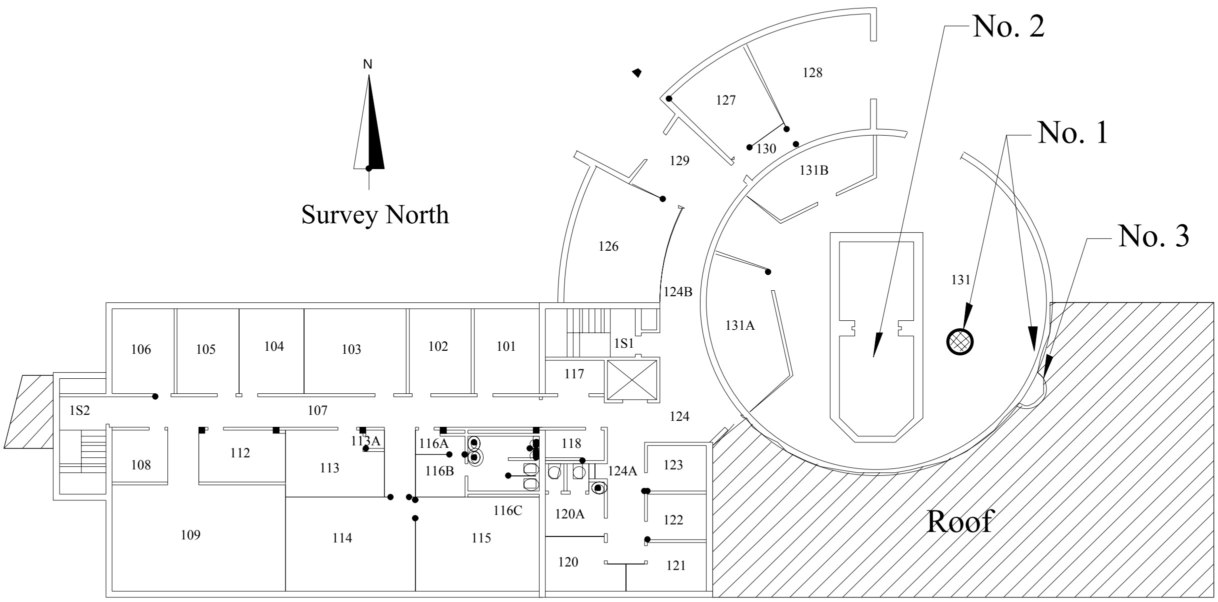


Figure A-2 UVA Reactor Facility Mezzanine Level

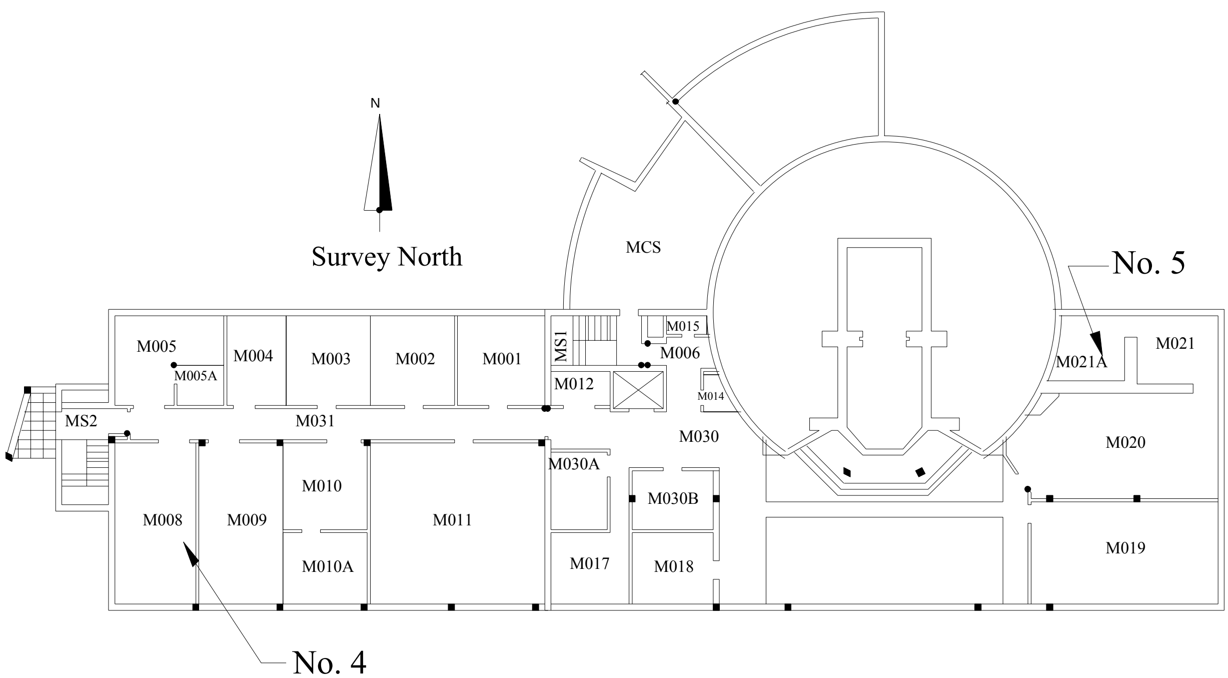


Figure A-3 UVA Reactor Facility Ground Level

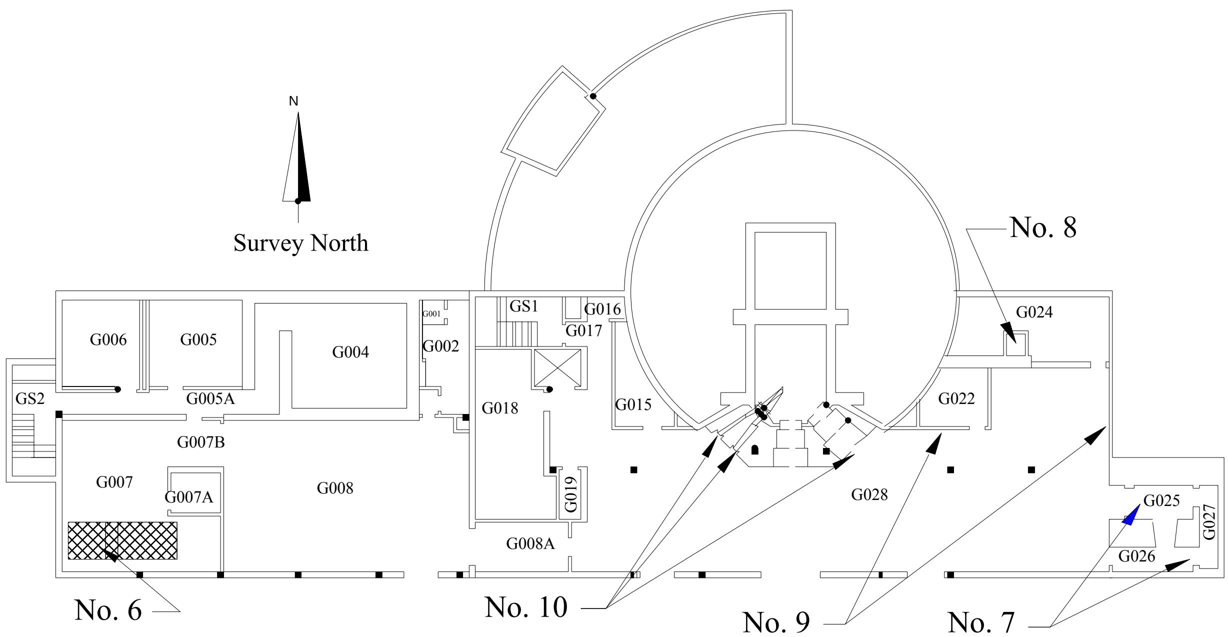
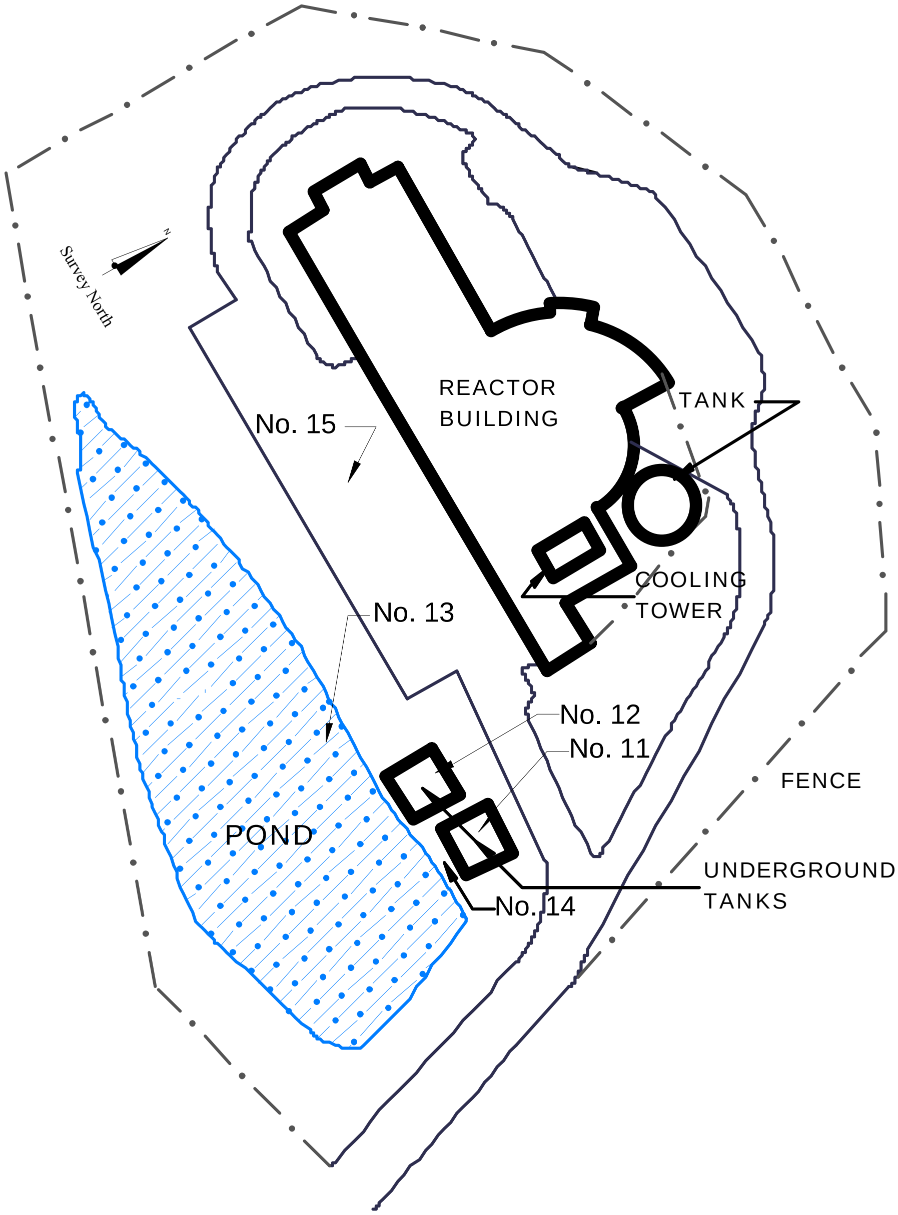


Figure A-4 UVA Reactor Facility Grounds



APPENDIX B

ENVIRONMENTAL REPORT